APPENDIX C

RAIL ROUTES TO THE PROPOSED PFSF SITE

As part of the evaluation of potential impacts in this final environmental impact statement (FEIS), an analysis was performed using the INTERLINE routing code and the RADTRAN risk assessment code (see Appendix D) to determine the transportation impacts associated with the rail shipment of commercial spent nuclear fuel (SNF). As described in this appendix, the INTERLINE computer code model was used to select rail routes and analyze the transportation scenarios.

Because of the size and weight of the SNF shipping casks included in the license application for the proposed Private Fuel Storage Facility (PFSF), it is assumed that all SNF will be shipped from existing reactor sites to the PFSF by rail. While shipment of SNF by truck over highways is possible, the size of the proposed shipping cask system to be used for the proposed facility makes the use of rail transportation essential for the transport of SNF. It should be noted that individual reactor licensees may need to move SNF form their sites by heavy-haul vehicles or barge in order to transfer SNF to railheads near their reactors.

C.1 Identification and Selection of Routes

The INTERLINE computer code was used to select routes and analyze the transportation scenarios (Johnson 1993). The INTERLINE model is designed to simulate routes on the rail system in the United States, and its database includes all railroads in the country. Several different routing options are available in the INTERLINE program, including “optimal” routes and alternative routing. The model can be modified to change routing parameters and interchange penalties (as explained below) between different railroad companies. Additional detailed routing analysis can be performed by blocking individual or sets of rail segments or intersections contained in the database.

The INTERLINE code selects routes based on several factors. The model maximizes the use of rail lines that are used for higher density traffic. If several railroads are available, the model minimizes the number of railroads used in the route. This is accomplished by placing a penalty for interchanges between railroad systems. Also, the originating railroad is preferentially used to maximize the distance traveled on their system.

The INTERLINE code was used to select routes accessing the proposed PFSF site in Skull Valley, Utah, as well as an alternate site in Wyoming. Section C.2 describes the routes in Utah, while Section C.3 discusses the Wyoming routes. Output pages from the INTERLINE code for these routes are provided in Sections C.4 and C.5. These output pages supply additional information including a listing of each rail route, as well as mileage and population density information.

In addition to the routes near the Skull Valley and Wyoming sites, a set of cross-country routes available from the Maine Yankee nuclear reactor (in Maine) was also identified. These cross-country routes are discussed in Section C.2. The INTERLINE output for the routes is displayed in Sections C.7 to C.13, which include cross-country routes to both Skull Valley and Wyoming, as well as the routes away from these locations toward the proposed candidate repository at Yucca Mountain, Nevada.

C.2 Rail Route From Maine Yankee to Skull Valley, Utah

For the purposes of this study, a representative route was chosen for analysis rather than analyzing all routes between every reactor and the Skull Valley site. The Maine Yankee reactor (in Maine) was selected for this analysis because it is one of the most distant reactors from the proposed PFSF. This route is shown in Figure C.1, is 4,476 km (2,781 miles) long, and involves five railroad companies. The Maine Coast Railroad (reporting mark MC) provides service to the Maine Yankee site and would transport the SNF shipment from the site to Brunswick, Maine, a distance of 50 km (31 miles). Traffic density on the MC is very low, less than 1 million gross ton-miles per mile (MGTM) annually, and this line is single track with no signal system. At Brunswick the shipment is transferred from MC to the ST Rail System (reporting mark ST). The ST Rail System would move the shipment for 472 km (293 miles) from Brunswick through southwestern Maine, southeastern New Hampshire, northern Massachusetts, to Mechanicville, New York, north of Albany. From Brunswick to near Portland, Maine, traffic density is less than 1 MGTM and the line is single track with no signals. From near Portland to Lawrence, Massachusetts, traffic density is between 5 to 10 MGTM and the line is single track with centralized traffic control (CTC) signals. Between Lawrence and Mechanicville, traffic density is 10 to 20 MGTM and the line is single track with CTC signals. At Mechanicville, the shipment would be transferred from ST to the St. Lawrence and Hudson operating subsidiary of the Canadian Pacific Railway (reporting mark CPRS). CPRS would move the shipment for 568 km (353 miles) between Mechanicville and Buffalo, New York, where the shipment would be transferred to the Norfolk Southern Railway (reporting mark NS). From Mechanicville to Binghamton, New York, traffic density is 10 to 20 MGTM and the line is single track with automatic block system (ABS) signals. The portion of the route between Binghamton to Buffalo has a traffic density of 20 to 30 MGTM and is primarily single track with a mixture of ABS and CTC signals. NS would handle the shipment for 851 km (529 miles) from Buffalo to Chicago where the shipment would be interchanged to the final carrier, the Union Pacific Railroad (reporting mark UP). The NS line between Buffalo and Chicago handles over 40 MGTM and is a mixture of single and double track with CTC signals. The UP would handle the shipment for 2,536 km (1,576 miles) from Chicago, through Illinois, Iowa, Nebraska, a short segment in Colorado, Wyoming, to the Skull Valley site in Utah. Traffic density from Chicago to west of Salt Lake City is over 40 MGTM. This segment of the route varies from single to double to triple track and signaling is either CTC or ABS. From Garfield, west of Salt Lake City to the spur to the Skull Valley site, traffic density is between 30 and 40 MGTM and the line is single track with CTC signals. The new 51-km (32-mile) rail line to the Skull Valley site would be single track with no signals and would have less than 1 MGTM annually.

Routes from the proposed PFSF to a Permanent National Repository. Congress, in the Nuclear Waste Policy Act, as amended (NWPA), has directed the DOE to study one candidate repository, namely, a repository proposed at Yucca Mountain, Nevada. To reflect the provisions of the NWPA, the NRC staff has examined the shipment of SNF via rail from the proposed PFSF, on its way to a permanent repository in the western United States, as if such a repository were located at Yucca Mountain, Nevada, although that location may or may not become the actual repository. Accordingly, the NRC staff examined the shipment of SNF via rail from the alternative Wyoming site to the Utah-Nevada border. The route analyzed in this FEIS stopped at the Utah-Nevada border because shipment plans beyond the border are subject to decisions of the DOE that have not yet been made (for example, the locations of intermodal transfer points or new direct-access rail lines). It should be

noted that the NRC has not received an application requesting a license for a permanent geological repository, and the NRC has not made any determination regarding any proposal to construct such a

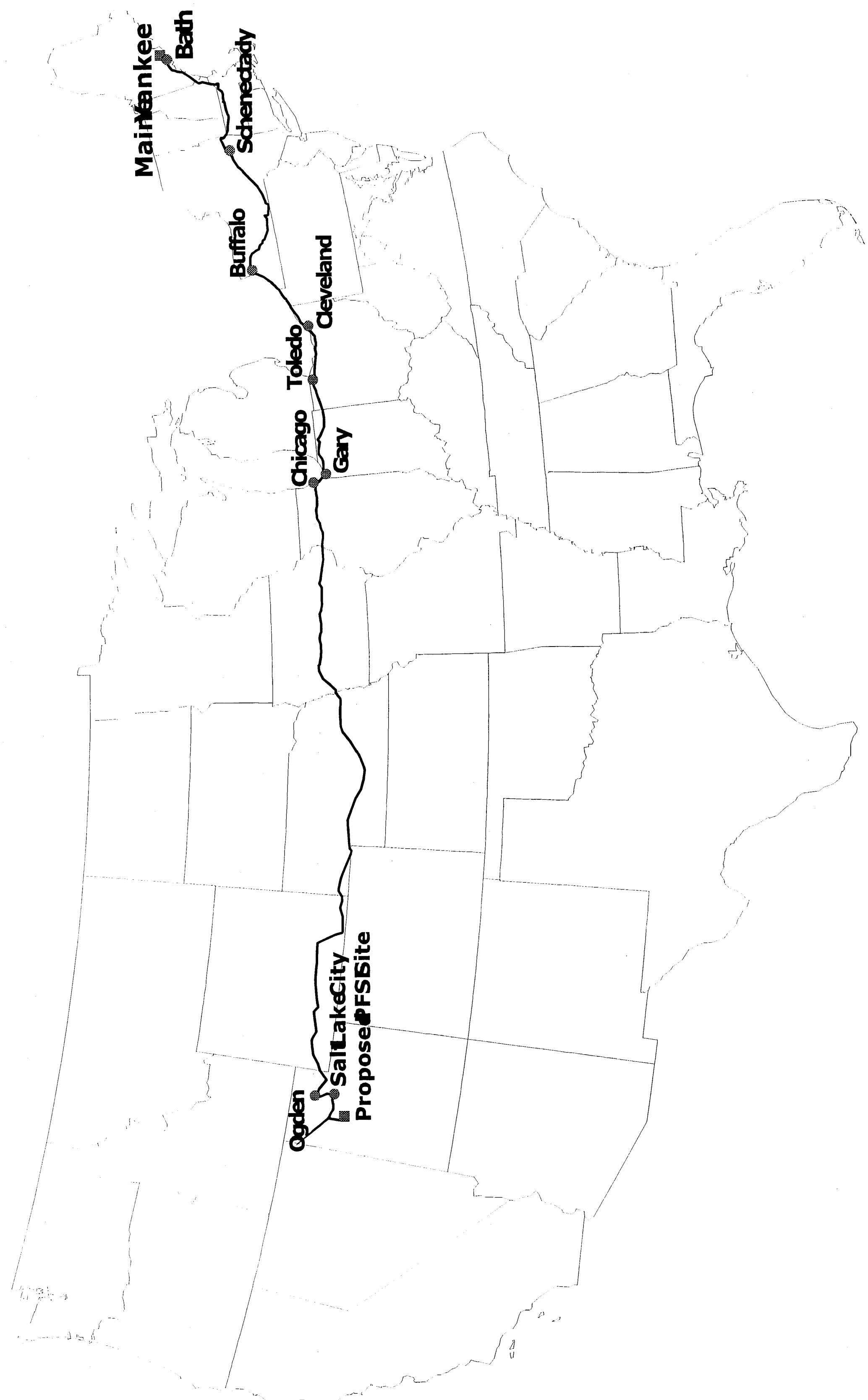

Figure C.1. Rail route from the Maine Yankee nuclear power plant to Skull Valley, Utah.

repository at Yucca Mountain, Nevada, or any other location.

This section describes the routes from the PFSF to the Utah-Nevada border on its way to a final repository in the western United States. If a new rail line is constructed linking the Union Pacific railroad main line to the Skull Valley site, shipments of SNF will move entirely by rail from Skull Valley to the Utah-Nevada state line in southwestern Utah (see Figure C.2). This route is 569 km (354 miles) long. The first 51 km (32 miles) of the route is on the rail line from the Skull Valley site to the UP mainline at Skunk Ridge. From Skunk Ridge, the route follows the UP Railroad east to Garfield and then south on another UP line through Lynndyl, Utah, to the Nevada state line in southwestern Utah near at a siding named Uvada. Traffic density from Skunk Ridge to Lynndyl is between 30 and 40 MGTM and from Lynndyl to the Nevada state line the traffic density increases to over 40 MGTM. This entire route is single track with CTC signaling.

C.3 Routes Near Skull Valley, Utah

Currently, there is no direct rail access to the proposed ISFSI site. This analysis assumes that a new 51-km (32-mile) rail line would be constructed from Skunk Ridge (located northeast of the proposed PFSF site and near the Low passing siding) to the proposed ISFSI site. The Union Pacific Railroad owns the existing rail line at Skunk Ridge.

For this study, rail access routes and route lengths were selected to cross the Utah state borders, where possible, and to accommodate convergence points from rail lines farther away from the proposed PFSF site. Five different access routes potentially could be used to reach the proposed site in Skull Valley, Utah (see Figure C.3). The actual distance of the identified routes varies from 330 km (220 miles) to 385 km (239 miles) due to the structure of the INTERLINE rail routing network. Note in Figure C.3 that the Skunk Ridge location may not appear to show precisely where the proposed rail line would leave the Union Pacific main line. The new rail line does intersect the main line at the Skunk Ridge location, but the new line closely parallels the main line for the first several miles. This is not visible in the figure due to the scale of this map.

The characteristics of each of the five routes, as described below, include information on the length of the route, the number of main tracks, the signaling of the line, and the volume of traffic density. These factors provide an indication of the capacity that each line segment can handle. Signals on railroads provide an additional margin of safety and greatly influence the number of trains that can operate over a line. Three general types of rail signaling are used in the United States. CTC is the most advanced type of signaling. With CTC, the dispatcher can control operations over a line with signal indications, and movements into passing sidings are assisted by remote controlled switches operated by the dispatcher. ABS is considerably less sophisticated than CTC. With ABS signals, the dispatcher controls train movements with orders provided by radio communication, and block signals provide indications to train crews whether another train is occupying a nearby rail segment. The third type of signal is no signal system. Rail operations are totally dependent upon radio communications between the train crew and the dispatcher.

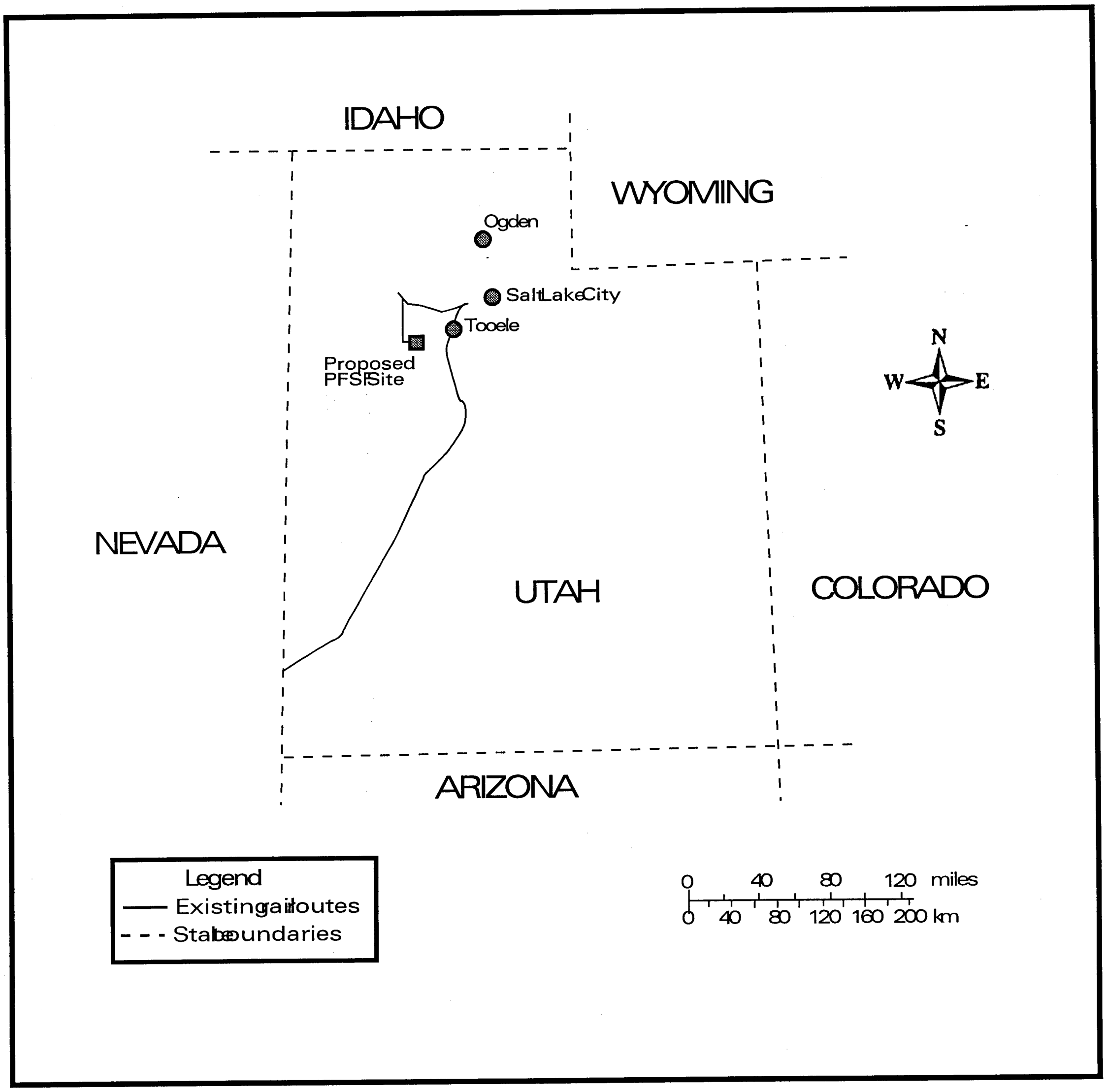

Figure C.2. Rail route for shipping SNF from Skull Valley, Utah, toward a national repository.

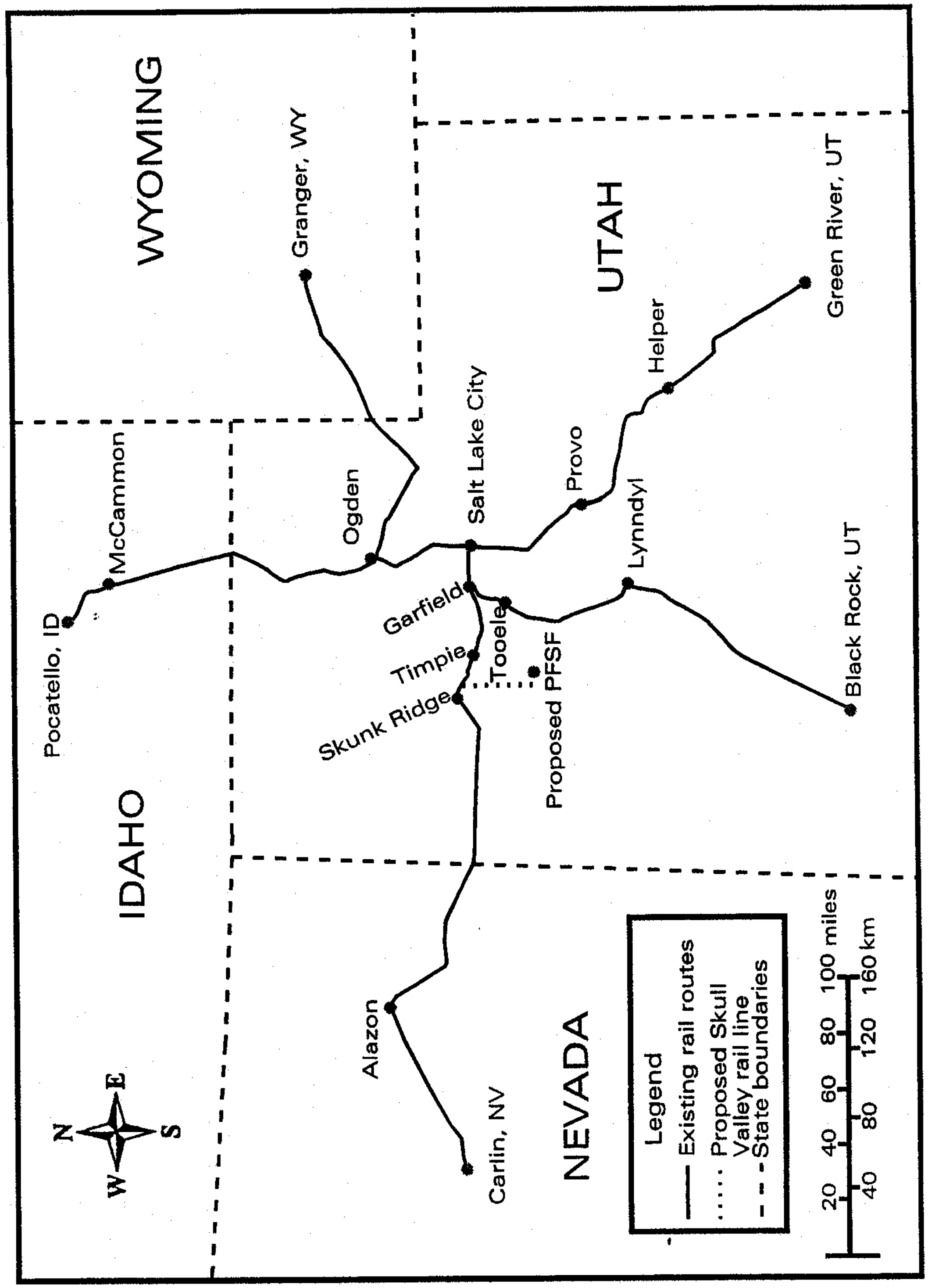

Figure C.3. Potential rail routes for shipping spent nuclear fuel to Skull Valley, Utah.

C.3.1 Route to Skull Valley from Granger, Wyoming

Due the number of nuclear utilities in the eastern United States, most SNF shipments will approach the proposed Skull Valley site via the route through Granger, Wyoming (see Figure C.3). This route follows the Union Pacific Railroad from Wyoming into northern Utah, passing through the larger cities of Ogden and Salt Lake City. From Salt Lake City, the route continues west through Garfield to a location called Skunk Ridge, where a new siding and new rail line would be constructed to reach the proposed PFSF site. The total length of this route from Granger is 357 km (222 miles). From Granger through Garfield, the Union Pacific is a dual-track mainline with a traffic density of over 40 MGTM annually. Most of the line between Granger and Ogden has ABS signals and the remainder of the route to Skunk Ridge has CTC signals. West of Garfield to the Skunk Ridge location, the Union Pacific is a single track mainline with a traffic density of 30 to 40 MGTM annually.

C.3.2 Route to Skull Valley from Green River, Utah

Reactor locations in Louisiana and Texas could use the route through Green River, Utah, to access the proposed site in Skull Valley. This route represents the second smallest potential number of shipments of SNF. This route has a total length of 380 km (236 miles) and extends from Green River through Provo to Salt Lake City. West of Salt Lake City, the route follows the same path described above to Skunk Ridge, where it would connect with the new rail line to the proposed facility. The entire route from Green River to Skunk Ridge is CTC signaled territory owned by the Union Pacific railroad. The number of tracks varies over this route. Single track exists from Green River to Helper (approximately midway between Green River and Provo), from Provo to Salt Lake City, and from Garfield to Skunk Ridge. Two main tracks exist between Helper and Provo and from Salt Lake City to Garfield.

C.3.3 Route to Skull Valley from Black Rock, Utah

Reactors in Arizona and southern California could access the Skull Valley site from Black Rock, Utah. This route has a length of 330 km (205 miles) and is entirely owned by the Union Pacific railroad. The route extends from Black Rock to Garfield, then west to Skunk Ridge, where it would connect with the new rail line to the proposed facility. This entire route is single track with CTC signaling. The first 114 km (71 miles) of the route between Black Rock and Lynndyl has traffic density over 40 MGTM. The remainder of the route from Lynndyl to Skunk Ridge has a traffic density between 30 and 40 MGTM. This route is also assumed to be used to ship SNF away from Skunk Ridge toward a national repository, although other routes could do so as well, depending on where a final repository is ultimately located.

C.3.4 Route to Skull Valley from Carlin, Nevada

The route through Carlin, Nevada, could be used to ship SNF from reactors located in northern California to the Skull Valley site. The length of this route between Carlin and the proposed ISFSI is 385 km (239 miles) and is entirely owned by the Union Pacific railroad. The entire route from Carlin to Skunk Ridge is single track and has a traffic density between 30 and 40 MGTM. From Carlin to Alazon, the line has ABS signals. The remainder of the route, between Alazon to Skunk Ridge, has CTC signals.

C.3.5 Route to Skull Valley from Pocatello, Idaho

The fifth and final access route to north-central Utah extends from Pocatello, Idaho, through Ogden and Salt Lake City to the proposed Skull Valley site. Reactors located in Oregon and Washington could use this route, which is 346 km (215 miles) long. Track characteristics vary for this route. Between Pocatello and McCammon, Idaho, the trackage is CTC signaled dual track with a traffic density over 40 MGTM. From McCammon to Ogden, Utah, the trackage is single track with ABS signals and a traffic density between 10 and 20 MGTM. Between Ogden and Garfield the trackage is CTC dual track with a traffic density over 40 MGTM. The final mainline segment of this route, between Garfield and Skunk Ridge is CTC single track with a traffic density between 30 and 40 MGTM.

C.4 Routes Near the Wyoming Site

An alternative site for the proposed facility in Fremont County, Wyoming, between the towns of Shoshoni and Bonneville, is also examined in this EIS. This site is located approximately 3 km (2 miles) from the Burlington Northern Santa Fe (BNSF) Railway mainline that runs through central Wyoming.

The INTERLINE rail routing model was used to examine possible rail access routes to the Wyoming site. As with the access routes identified for the Utah site, the actual distances of the routes to the Wyoming site vary [from 350 km (220 miles) to 400 km (250 miles)] due to the structure of the INTERLINE rail routing network. Four different access routes could be used to service the alternative site in Wyoming. These rail routes are shown in Figure C.4.

C.4.1 Route to Fremont County from Crandall, Wyoming

The access route from Crandall, Wyoming, to the alternative site near Bonneville could be used by several commercial nuclear reactors in the Midwest that are served by the Union Pacific Railroad. This 350-km (220-mile) route would use the Union Pacific Railroad from Crandall to Shawnee Junction, Wyoming, where Union Pacific Railroad has trackage rights on the BNSF to Casper, Wyoming. At Casper, the traffic would be interchanged to the BNSF for the remainder of the route to Bonneville, Wyoming. Between Crandall and Shawnee Junction, the Union Pacific line alternates between singe and dual track sections, has CTC signaling, and has a traffic density of over 40 MGTM. From Shawnee Junction to Orin, the line is single track, has CTC signaling, and also has a traffic density over 40 MGTM. The final portion of this route from Orin to Bonneville is single track with no signaling and has a traffic density between 10 and 20 MGTM.

C.4.2 Route to Fremont County from Mitchell, Nebraska

Shipments of SNF from most commercial nuclear reactors in the eastern United States would access the alternative site near Bonneville via the route through Mitchell, Nebraska. This route follows the BNSF from Mitchell, near the Nebraska-Wyoming border to Bonneville, Wyoming, and is 400 km (250 miles) long. From Mitchell to Orin, Wyoming, the rail line is single track with CTC signals and has a traffic density over 40 MGTM. Between Orin and Bonneville, the line is single track with no signaling and has a traffic density between 10 and 20 MGTM.

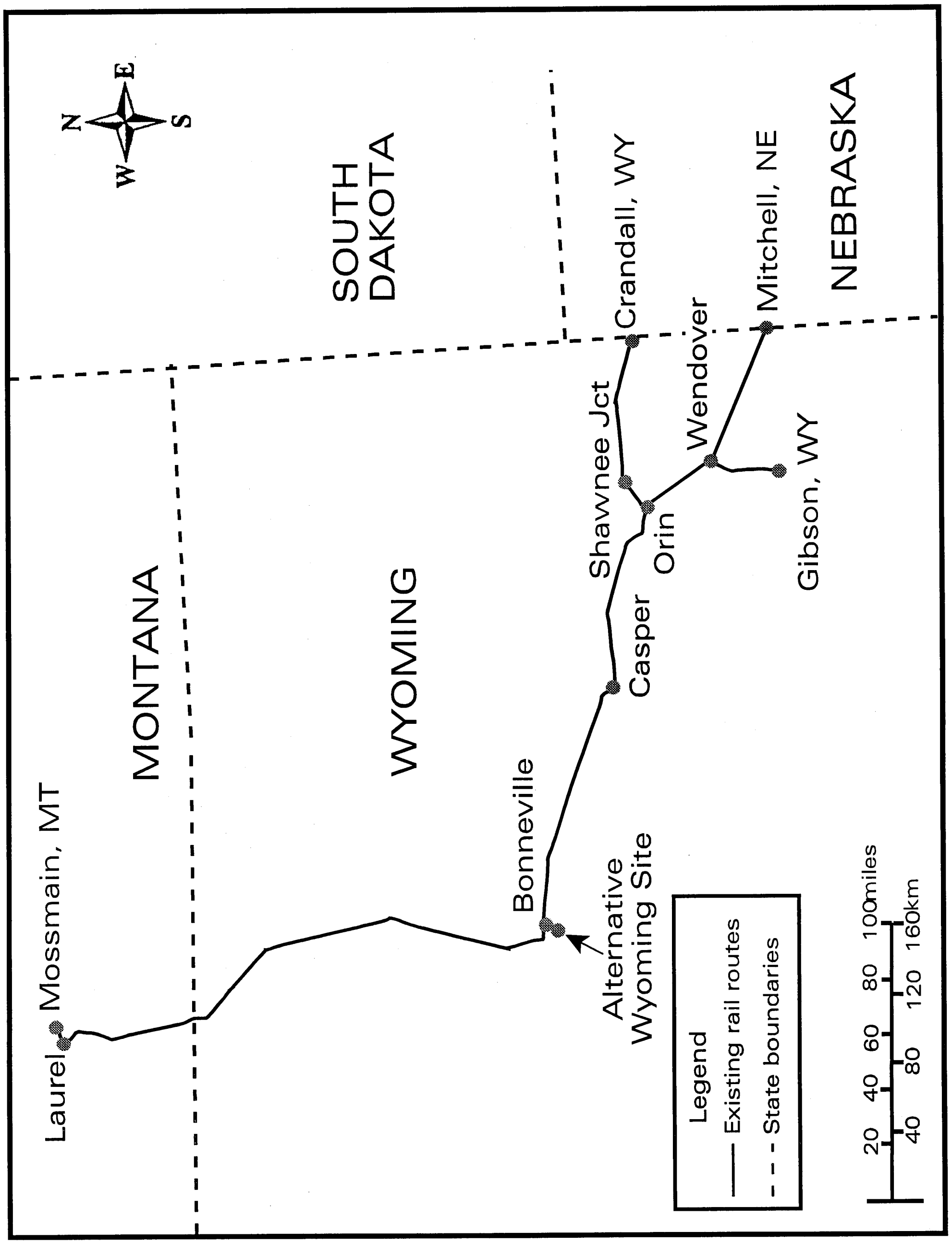

Figure C.4. Potential rail routes for shipping spent nuclear fuel to Fremont County, Wyoming.

C.4.3 Route to Fremont County from Gibson, Wyoming

SNF from southwestern states, including California through Texas, could use the Gibson, Wyoming, access route. This 370-km (230-mile) route follows the BNSF Railway from Gibson to Bonneville. From Gibson to Wendover, Wyoming, and from Orin to Bonneville, the rail line is single track with no signals and has a traffic density between 10 and 20 MGTM. The portion of the route between Wendover and Orin is single track with CTC signals and has a traffic density of over 40 MGTM.

C.4.4 Route to Fremont County from Mossmain, Montana

The fourth and final access route to the alternative site near Bonneville is from Mossmain, Montana, to Bonneville. This route could be used by commercial nuclear reactors located in the Pacific Northwest, as well as one of the reactors in Minnesota. BNSF would transport the shipment over this 365-km (227-mile) route. From Mossmain to Laurel, Montana, the route in on single track, ABS signaled line owned by the Montana Rail Link company. This segment has a traffic density between 20 and 30 MGTM. The remainder of the route from Laurel to Bonneville is on BNSF-owned line that is single track with no signaling and has a traffic density between 10 and 20 MGTM.

C.5 Interline Output for Routes Near the Skull Valley, Utah, Site

C.5.1 Route Between Granger, Wyoming and the Utah PFSF Site

```
    ROUTE FROM:  UP   13494-GRANGER             WY     LENGTH:   275.7 MILES
            TO:  UP   16153-PFSF                UT  POTENTIAL:  297.36


   MILEAGE SUMMARY BY RAILROAD          A-M   B-M   A-BR  B-BR  OTHER
                        UP    275.7    243.7    .0    .0  32.0     .0
                             -  -  -  -  -  -  -  -  -  -  -  -  -  -
                      TOTAL   275.7    243.7    .0    .0  32.0     .0
    MILEAGE SUMMARY BY STATE
            206.1-UT     69.6-WY


      RR      NODE            STATE  DIST
     UP   13494-GRANGER         WY     0.
     UP   13568-OGDEN           UT   143.
     UP   13595-SALT LAKE CITY  UT   179.
     UP   13594-GARFIELD        UT   191.
     UP   16153-PFSF            UT   276.

    POPULATION DENSITY FROM:  UP   13494-GRANGER             WY
                        TO:  UP   16153-PFSF                UT

          ------------------  MILEAGE WITHIN DENSITY LEVELS  -------------------
                <0.0   5.0  22.7  59.7   139   326   821  1861  3326  5815
 St Miles    0  -5.0 -22.7 -59.7  -139  -326  -821 -1861 -3326 -5815 -9996 >9996
 ------------------------------------------------------------------------------

 UT 206.1 67.5  76.3  26.7   2.9   2.4   2.7   4.8   7.0   7.2   6.4   2.0    .2
 WY  69.6 20.6  48.5    .5    .0    .0    .0    .0    .0    .0    .0    .0    .0

 Totals
    275.7 88.1 124.8  27.2   2.9   2.4   2.7   4.8   7.0   7.2   6.4   2.0    .2
 Percentages
          31.9  45.3   9.9   1.1    .9   1.0   1.7   2.6   2.6   2.3    .7    .1
 Basis: 1990 Census data

    RADTRAN Input Data      Rural Suburban    Urban

    Weighted Population
         People/sq. mi.       4.3   1448.1   5461.4
         People/sq. km.       1.6    559.1   2108.6

    Distance                                        Total
         Miles              245.4     21.7      8.6   275.7
         Kilometers         395.0     34.9     13.9   443.7
         Percentage          89.0      7.9      3.1

    Basis (people/sq. mi.)   <139 139-3326    >3326

    Note: Due to rounding, the sum of the mileages in the individual
          population categories may not equal the total mileage shown
          on this report.
```

C.5.2 Route Between Green River, Utah and the Utah PFSF Site

ROUTE FROM:	UP	13635-GREEN RIVER	UT	LENGTH:	290.3 MILES
TO:	UP	16153-PFSF	UT	POTENTIAL:	309.04

MILEAGE SUMMARY BY RAILROAD

		A-M	B-M	A-BR	B-BR	OTHER
UP	290.3	258.3	.0	.0	32.0	.0
TOTAL	290.3	258.3	.0	.0	32.0	.0

MILEAGE SUMMARY BY STATE
290.3-UT

RR	NODE	STATE	DIST
UP	13635-GREEN RIVER	UT	0.
UP	13613-THISTLE	UT	130.
UP	13611-SPRINGVILLE	UT	144.
UP	13610-PROVO	UT	149.
UP	13609-GENEVA	UT	156.
UP	13593-PALLAS	UT	186.
UP	13595-SALT LAKE CITY	UT	193.
UP	13594-GARFIELD	UT	205.
UP	16153-PFSF	UT	290.

POPULATION DENSITY FROM:	UP	13635-GREEN RIVER	UT
TO:	UP	16153-PFSF	UT

------------------ MILEAGE WITHIN DENSITY LEVELS -------------------

St	Miles	0	<0.0 -5.0	5.0 -22.7	22.7 -59.7	59.7 -139	139 -326	326 -821	821 -1861	1861 -3326	3326 -5815	5815 -9996	>9996
UT	290.3	117.8	101.6	15.3	8.1	7.8	7.0	8.9	13.2	5.9	3.8	.9	.1
Totals	290.3	117.8	101.6	15.3	8.1	7.8	7.0	8.9	13.2	5.9	3.8	.9	.1
Percentages		40.6	35.0	5.3	2.8	2.7	2.4	3.1	4.5	2.0	1.3	.3	.0

Basis: 1990 Census data

RADTRAN Input Data	Rural	Suburban	Urban	Total
Weighted Population				
People/sq. mi.	6.3	1135.0	5304.1	
People/sq. km.	2.4	438.2	2047.9	
Distance				
Miles	250.5	35.0	4.8	290.3
Kilometers	403.1	56.3	7.8	467.2
Percentage	86.3	12.1	1.7	
Basis (people/sq. mi.)	<139	139-3326	>3326	

Note: Due to rounding, the sum of the mileages in the individual population categories may not equal the total mileage shown on this report.

C.5.3 Route Between Black Rock, Utah and the Utah PFSF Site

```
    ROUTE FROM:  UP   13619-BLACK ROCK          UT     LENGTH:   259.0 MILES
            TO:  UP   16153-PFSF                UT  POTENTIAL:  284.00


   MILEAGE SUMMARY BY RAILROAD          A-M   B-M   A-BR  B-BR  OTHER
                        UP    259.0    227.0    .0    .0  32.0     .0
                             -  -  -  -  -  -  -  -  -  -  -  -  -  -
                      TOTAL   259.0    227.0    .0    .0  32.0     .0
    MILEAGE SUMMARY BY STATE
            259.0-UT


      RR      NODE            STATE  DIST
     UP   13619-BLACK ROCK      UT     0.
     UP   13630-LYNNDYL         UT    71.
     UP   13594-GARFIELD        UT   174.
     UP   16153-PFSF            UT   259.


    POPULATION DENSITY FROM:  UP   13619-BLACK ROCK          UT
                        TO:  UP   16153-PFSF                UT

          ------------------  MILEAGE WITHIN DENSITY LEVELS  -------------------
              <0.0   5.0  22.7  59.7   139   326   821  1861  3326  5815
  St Miles    0  -5.0 -22.7 -59.7  -139  -326  -821 -1861 -3326 -5815 -9996 >9996
  -------------------------------------------------------------------------------

  UT 259.0100.8 120.5  27.5   4.6   2.2    .9    .7   1.4    .5    .0    .0    .0

  Totals
     259.0100.8 120.5  27.5   4.6   2.2    .9    .7   1.4    .5    .0    .0    .0
  Percentages
          38.9  46.5  10.6   1.8    .9    .3    .3    .5    .2    .0    .0    .0
  Basis: 1990 Census data

     RADTRAN Input Data      Rural Suburban    Urban

     Weighted Population
          People/sq. mi.       4.3   1076.3       .0
          People/sq. km.       1.6    415.5       .0

     Distance                                         Total
          Miles              255.5      3.5       .0   259.0
          Kilometers         411.3      5.6       .0   416.8
          Percentage          98.7      1.3       .0

     Basis (people/sq. mi.)   <139 139-3326    >3326

     Note: Due to rounding, the sum of the mileages in the individual
           population categories may not equal the total mileage shown
           on this report.
```

C.5.4 Route Between Carlin, Nevada, and the Utah PFSF Site

```
    ROUTE FROM:  UP   14792-CARLIN             NV     LENGTH:   248.0 MILES
            TO:  UP   16153-PFSF               UT  POTENTIAL:  275.20


   MILEAGE SUMMARY BY RAILROAD          A-M   B-M   A-BR  B-BR  OTHER
                      UP    248.0    216.0    .0    .0  32.0     .0
                                -  -  -  -  -  -  -  -  -  -  -  -  -  -
                    TOTAL   248.0    216.0    .0    .0  32.0     .0
    MILEAGE SUMMARY BY STATE
            162.0-NV     86.0-UT


      RR      NODE            STATE  DIST
     UP   14792-CARLIN          NV     0.
     UP   14793-ELKO            NV    20.
     UP   14794-ALAZON          NV    71.
     UP   14795-WELLS           NV    75.
     UP   14797-SHAFTER         NV   121.
     UP   16153-PFSF            UT   248.



    POPULATION DENSITY FROM:  UP   14792-CARLIN              NV
                        TO:  UP   16153-PFSF                UT

          ------------------  MILEAGE WITHIN DENSITY LEVELS  -------------------
                <0.0   5.0  22.7  59.7   139   326   821  1861  3326  5815
 St Miles    0  -5.0 -22.7 -59.7  -139  -326  -821 -1861 -3326 -5815 -9996 >9996
 -------------------------------------------------------------------------------

 NV 162.0 21.9 109.1  16.6   6.6   4.8   1.3   1.2    .5    .0    .0    .0    .0
 UT  86.0 81.7   3.1   1.2    .0    .0    .0    .0    .0    .0    .0    .0    .0

 Totals
    248.0103.7 112.1  17.8   6.6   4.8   1.3   1.2    .5    .0    .0    .0    .0
 Percentages
          41.8  45.2   7.2   2.7   2.0    .5    .5    .2    .0    .0    .0    .0
 Basis: 1990 Census data

    RADTRAN Input Data      Rural Suburban    Urban

    Weighted Population
         People/sq. mi.       5.2    553.6       .0
         People/sq. km.       2.0    213.7       .0

    Distance                                          Total
         Miles              245.1      2.9       .0   248.0
         Kilometers         394.4      4.7       .0   399.1
         Percentage          98.8      1.2       .0

    Basis (people/sq. mi.)   <139 139-3326    >3326

    Note: Due to rounding, the sum of the mileages in the individual
          population categories may not equal the total mileage shown
          on this report.
```

C.5.5 Route Between Pocatello, Idaho, and the Utah PFSF Site

```
ROUTE FROM:  UP   13370-POCATELLO          ID     LENGTH:   269.1 MILES
        TO:  UP   16153-PFSF               UT  POTENTIAL:  310.24
```

MILEAGE SUMMARY BY RAILROAD		A-M	B-M	A-BR	B-BR	OTHER
UP	269.1	123.6	113.5	.0	32.0	.0
TOTAL	269.1	123.6	113.5	.0	32.0	.0

MILEAGE SUMMARY BY STATE
72.0-ID   197.1-UT

RR	NODE	STATE	DIST
UP	13370-POCATELLO	ID	0.
UP	13369-MC CAMMON	ID	23.
UP	13568-OGDEN	UT	137.
UP	13595-SALT LAKE CITY	UT	172.
UP	13594-GARFIELD	UT	184.
UP	16153-PFSF	UT	269.

```
POPULATION DENSITY FROM:  UP   13370-POCATELLO          ID
                     TO:  UP   16153-PFSF               UT
```

MILEAGE WITHIN DENSITY LEVELS

St	Miles	0	<0.0 -5.0	5.0 -22.7	22.7 -59.7	59.7 -139	139 -326	326 -821	821 -1861	1861 -3326	3326 -5815	5815 -9996	>9996
ID	72.0	4.5	13.4	42.2	8.7	1.3	.8	.3	.7	.0	.0	.0	.0
UT	197.1	80.8	40.9	14.4	16.4	9.1	7.3	7.2	7.4	6.5	5.6	1.5	.0
Totals	269.1	85.3	54.3	56.6	25.1	10.5	8.0	7.5	8.1	6.5	5.6	1.5	.0
Percentages		31.7	20.2	21.0	9.3	3.9	3.0	2.8	3.0	2.4	2.1	.5	.0

Basis: 1990 Census data

RADTRAN Input Data	Rural	Suburban	Urban	Total
Weighted Population				
People/sq. mi.	12.9	1124.7	5270.8	
People/sq. km.	5.0	434.2	2035.0	
Distance				
Miles	231.9	30.1	7.1	269.1
Kilometers	373.1	48.5	11.4	433.1
Percentage	86.2	11.2	2.6	
Basis (people/sq. mi.)	<139	139-3326	>3326	

Note: Due to rounding, the sum of the mileages in the individual population categories may not equal the total mileage shown on this report.

C.6 Interline Output for Routes Near the Fremont County, Wyoming, Site

C.6.1 Route Between Crandall, Wyoming, and the Alternative PFSF Site

```
   ROUTE FROM:  UP   11264-CRANDALL            WY     LENGTH:   219.9 MILES
           TO:  BNSF 13499-BONNEVILLE          WY  POTENTIAL:  544.22

  MILEAGE SUMMARY BY RAILROAD          A-M   B-M   A-BR  B-BR  OTHER
                         BNSF  100.0       .0 100.0    .0    .0     .0
                         UP    119.9     48.0  64.4    .0   7.5     .0
                              -  -  -  -  -  -  -  -  -  -  -  -  -  -
                       TOTAL   219.9     48.0 164.4    .0   7.5     .0
   MILEAGE SUMMARY BY STATE
           219.9-WY

     RR      NODE            STATE  DIST
    UP   11264-CRANDALL        WY     0.
    UP   13474-CASPER          WY   120.
   - - - - - - - - - - - - - - - - - - - - - - - - TRANSFER
    BNSF 13474-CASPER          WY   120.
    BNSF 13499-BONNEVILLE      WY   220.


   POPULATION DENSITY FROM:  UP   11264-CRANDALL            WY
                       TO:  BNSF 13499-BONNEVILLE          WY

         ------------------  MILEAGE WITHIN DENSITY LEVELS  -------------------
               <0.0   5.0  22.7  59.7   139   326   821  1861  3326  5815
St Miles    0  -5.0 -22.7 -59.7  -139  -326  -821 -1861 -3326 -5815 -9996 >9996
-------------------------------------------------------------------------------

WY 219.9 31.9 153.8  16.4   4.4   1.2   3.1   4.3   1.4    .7   1.2   1.3    .2

Totals
   219.9 31.9 153.8  16.4   4.4   1.2   3.1   4.3   1.4    .7   1.2   1.3    .2
Percentages
         14.5  70.0   7.5   2.0    .5   1.4   2.0    .7    .3    .5    .6    .1
Basis: 1990 Census data

   RADTRAN Input Data      Rural Suburban    Urban

   Weighted Population
        People/sq. mi.       4.4    719.2   6584.6
        People/sq. km.       1.7    277.7   2542.3

   Distance                                          Total
        Miles              207.7      9.5      2.6    219.9
        Kilometers         334.3     15.3      4.3    353.9
        Percentage          94.5      4.3      1.2

   Basis (people/sq. mi.)   <139 139-3326    >3326

   Note: Due to rounding, the sum of the mileages in the individual
         population categories may not equal the total mileage shown
         on this report.
```

C.6.2 Route Between Mitchell, Nebraska, and the Alternative PFSF Site

ROUTE FROM:	BNSF 11265-MITCHELL	NE	LENGTH:	250.4 MILES
TO:	BNSF 13499-BONNEVILLE	WY	POTENTIAL:	226.62

MILEAGE SUMMARY BY RAILROAD		A-M	B-M	A-BR	B-BR	OTHER
BNSF	250.4	86.0	164.4	.0	.0	.0
TOTAL	250.4	86.0	164.4	.0	.0	.0

MILEAGE SUMMARY BY STATE
250.4-WY

RR	NODE	STATE	DIST
BNSF	11265-MITCHELL	NE	0.
BNSF	13470-GUERNSEY	WY	41.
BNSF	13474-CASPER	WY	150.
BNSF	13499-BONNEVILLE	WY	250.

POPULATION DENSITY FROM:	BNSF 11265-MITCHELL	NE
TO:	BNSF 13499-BONNEVILLE	WY

MILEAGE WITHIN DENSITY LEVELS

St	Miles	0	<0.0 -5.0	5.0 -22.7	22.7 -59.7	59.7 -139	139 -326	326 -821	821 -1861	1861 -3326	3326 -5815	5815 -9996	>9996
WY	250.4	41.1	163.6	21.9	6.4	3.5	4.7	4.3	1.4	.7	1.2	1.3	.2
Totals													
	250.4	41.1	163.6	21.9	6.4	3.5	4.7	4.3	1.4	.7	1.2	1.3	.2
Percentages													
		16.4	65.3	8.8	2.6	1.4	1.9	1.7	.6	.3	.5	.5	.1

Basis: 1990 Census data

RADTRAN Input Data	Rural	Suburban	Urban	Total
Weighted Population				
People/sq. mi.	5.6	650.1	6584.6	
People/sq. km.	2.2	251.0	2542.3	
Distance				
Miles	236.6	11.1	2.6	250.4
Kilometers	380.8	17.9	4.3	403.0
Percentage	94.5	4.4	1.1	
Basis (people/sq. mi.)	<139	139-3326	>3326	

Note: Due to rounding, the sum of the mileages in the individual population categories may not equal the total mileage shown on this report.

C.6.3 Route Between Gibson, Wyoming, and the Alternative PFSF Site

```
   ROUTE FROM:  BNSF 13468-GIBSON              WY     LENGTH:   230.4 MILES
           TO:  BNSF 13499-BONNEVILLE          WY  POTENTIAL:  215.26


  MILEAGE SUMMARY BY RAILROAD           A-M   B-M   A-BR  B-BR  OTHER
                      BNSF  230.4     37.0 193.4    .0    .0     .0
                                 -  -  -  -  -  -  -  -  -  -  -  -  -  -
                    TOTAL   230.4     37.0 193.4    .0    .0     .0
   MILEAGE SUMMARY BY STATE
           230.4-WY


     RR      NODE            STATE  DIST
    BNSF 13468-GIBSON          WY     0.
    BNSF 13474-CASPER          WY   130.
    BNSF 13499-BONNEVILLE      WY   230.



   POPULATION DENSITY FROM:  BNSF 13468-GIBSON               WY
                        TO:  BNSF 13499-BONNEVILLE           WY

         ------------------  MILEAGE WITHIN DENSITY LEVELS  -------------------
              <0.0   5.0  22.7  59.7   139   326   821  1861  3326  5815
St Miles    0  -5.0 -22.7 -59.7  -139  -326  -821 -1861 -3326 -5815 -9996 >9996
-------------------------------------------------------------------------------

WY 230.4 32.4 148.4  26.9   7.8   2.4   3.5   4.3   1.4    .7   1.2   1.3    .2

Totals
   230.4 32.4 148.4  26.9   7.8   2.4   3.5   4.3   1.4    .7   1.2   1.3    .2
Percentages
         14.0  64.4  11.7   3.4   1.0   1.5   1.9    .6    .3    .5    .6    .1
Basis: 1990 Census data

   RADTRAN Input Data      Rural Suburban    Urban

   Weighted Population
        People/sq. mi.       6.0    701.4   6584.6
        People/sq. km.       2.3    270.8   2542.3

   Distance                                         Total
        Miles              217.9      9.9      2.6   230.4
        Kilometers         350.6     15.9      4.3   370.8
        Percentage          94.6      4.3      1.1

   Basis (people/sq. mi.)   <139 139-3326    >3326

   Note: Due to rounding, the sum of the mileages in the individual
         population categories may not equal the total mileage shown
         on this report.
```

C.6.4 Route Between Mossmain, Montana, and the Alternative PFSF Site

```
   ROUTE FROM:  BNSF 13210-MOSSMAIN            MT     LENGTH:   226.9 MILES
           TO:  BNSF 13499-BONNEVILLE          WY  POTENTIAL:  217.82


  MILEAGE SUMMARY BY RAILROAD           A-M   B-M   A-BR  B-BR  OTHER
                      BNSF  226.9       .0 226.9    .0    .0     .0
                              -  -  -  -  -  -  -  -  -  -  -  -  -  -
                     TOTAL   226.9       .0 226.9    .0    .0     .0
   MILEAGE SUMMARY BY STATE
            56.0-MT    170.9-WY


     RR      NODE            STATE  DIST
    BNSF 13210-MOSSMAIN        MT     0.
    BNSF 13211-LAUREL          MT     4.
    BNSF 13499-BONNEVILLE      WY   227.



   POPULATION DENSITY FROM:  BNSF 13210-MOSSMAIN           MT
                        TO:  BNSF 13499-BONNEVILLE         WY

         ------------------  MILEAGE WITHIN DENSITY LEVELS  -------------------
               <0.0   5.0  22.7  59.7   139   326   821  1861  3326  5815
St Miles    0  -5.0 -22.7 -59.7  -139  -326  -821 -1861 -3326 -5815 -9996 >9996
-----------------------------------------------------------------------------------

MT  56.0   .0  37.0   9.2   7.1   1.3    .5    .2    .6    .0    .0    .0    .0
WY 170.9 21.1 106.4  32.8   6.6   2.0    .3    .2    .5    .4    .6    .0    .0

Totals
   226.9 21.1 143.4  42.0  13.7   3.3    .8    .5   1.1    .4    .6    .0    .0
Percentages
          9.3  63.2  18.5   6.0   1.4    .3    .2    .5    .2    .3    .0    .0
Basis: 1990 Census data

   RADTRAN Input Data      Rural Suburban    Urban

   Weighted Population
        People/sq. mi.       8.2   1096.1   4570.5
        People/sq. km.       3.2    423.2   1764.7

   Distance                                        Total
        Miles              223.5      2.8       .6    226.9
        Kilometers         359.7      4.4      1.0    365.2
        Percentage          98.5      1.2       .3

   Basis (people/sq. mi.)   <139 139-3326    >3326

   Note: Due to rounding, the sum of the mileages in the individual
         population categories may not equal the total mileage shown
         on this report.
```

C.7 Interline Output for the Route Between the Maine Yankee Nuclear Plant (in Maine) and Skull Valley, Utah

```
 INTERLINE 5.10  NETWORK 14.00

 ROUTE FROM:  <C3>    96-MAINE YANKEE NP      ME     LENGTH:  2781.3 MILES
         TO:  UP   16153-PFSF                UT  POTENTIAL:  3778.4


MILEAGE SUMMARY BY RAILROAD           A-M   B-M   A-BR  B-BR  OTHER
                     CPRS  352.7    209.8 142.9    .0    .0     .0
                     NS    528.9    521.9   7.0    .0    .0     .0
                     UP   1575.7   1531.9  11.8    .0  32.0     .0
                     ST    293.0       .0 278.0    .0  15.0     .0
                     <C3>   31.0       .0    .0    .0  31.0     .0
                          -  -  -  -  -  -  -  -  -  -  -  -  -  -
                   TOTAL  2781.3   2263.6 439.7    .0  78.0     .0
 MILEAGE SUMMARY BY STATE
          10.0-CO    150.9-IL    148.4-IN    336.2-IA    100.9-ME
         151.0-MA    451.5-NE     31.4-NH    460.4-NY    245.9-OH
          44.0-PA    206.1-UT      6.0-VT    438.6-WY



   RR      NODE            STATE  DIST
  <C3>    96-MAINE YANKEE NP ME     0.
  <C3>   121-BRUNSWICK       ME    31.
 - - - - - - - - - - - - - - - - - - - - - - - - - TRANSFER
  ST     121-BRUNSWICK       ME    31.
  ST     135-YARMOUTH JCT    ME    45.
  ST     132-PORTLAND        ME    61.
  ST     142-DOVER           NH   112.
  ST     291-LAWRENCE        MA   147.
  ST     299-LOWELL          MA   160.
  ST     423-AYER            MA   177.
  ST     432-FITCHBURG       MA   190.
  ST     447-MILLERS FALLS   MA   237.
  ST     454-GREENFIELD      MA   243.
  ST     694-MECHANICVILLE   NY   324.
 - - - - - - - - - - - - - - - - - - - - - - - - - TRANSFER
  CPRS   694-MECHANICVILLE   NY   324.
  CPRS   706-SCHENECTADY     NY   337.
  CPRS  1037-BINGHAMTON      NY   467.
  CPRS  1039-WAVERLY         NY   507.
  CPRS  1008-ELMIRA          NY   525.
  CPRS  1009-CORNING         NY   543.
  CPRS   881-NIAGARA JCT     NY   665.
  CPRS   880-BUFFALO         NY   677.
 - - - - - - - - - - - - - - - - - - - - - - - - - TRANSFER
  NS     880-BUFFALO         NY   677.
  NS     938-DUNKIRK         NY   718.
  NS     942-WESTFIELD       NY   742.
  NS     968-ERIE            PA   771.
  NS    2652-CONNEAUT        OH   795.
  NS    2649-ASHTABULA       OH   809.
  NS    2727-PAINESVILLE     OH   835.
  NS    2728-CLEVELAND       OH   865.
  NS    2633-ELYRIA          OH   892.
  NS   14985-OAK HARBOR      OH   949.
  NS    3442-TOLEDO          OH   971.
  NS    3526-GOSHEN          IN  1093.
  NS    3525-ELKHART         IN  1103.
  NS    4022-SOUTH BEND      IN  1118.
  NS    3969-LA PORTE        IN  1144.
```

NS	4067-PORTER	IN	1163.
NS	4069-MILLER	IN	1173.
NS	4070-GARY	IN	1178.
NS	4073-CLARKE	IN	1182.
NS	4074-INDIANA HARBOR	IN	1185.
NS	4035-WHITING LAKE FRO	IN	1188.
NS	4232-SOUTH CHICAGO	IL	1193.
NS	4217-CHICAGO	IL	1206.
- -			TRANSFER
UP	4217-CHICAGO	IL	1206.
UP	4234-PROVISO	IL	1220.
UP	4214-WEST CHICAGO	IL	1235.
UP	4311-DE KALB	IL	1262.
UP	4324-NELSON	IL	1307.
UP	10304-CLINTON	IA	1342.
UP	10289-CEDAR RAPIDS	IA	1423.
UP	10265-MARSHALLTOWN	IA	1492.
UP	10246-NEVADA	IA	1519.
UP	10271-AMES	IA	1530.
UP	10177-ARION	IA	1628.
UP	10176-MISSOURI VALLEY	IA	1664.
UP	10198-CALIFORNIA JCT	IA	1670.
UP	11340-FREMONT	NE	1698.
UP	11473-CENTRAL CITY	NE	1785.
UP	11406-GRAND ISLAND	NE	1807.
UP	11410-GIBBON	NE	1833.
UP	11352-NORTH PLATTE	NE	1952.
UP	11358-O FALLONS	NE	1964.
UP	13703-JULESBURG	CO	2032.
UP	11287-SIDNEY	NE	2075.
UP	13465-CHEYENNE	WY	2178.
UP	13462-LARAMIE	WY	2230.
UP	13494-GRANGER	WY	2506.
UP	13568-OGDEN	UT	2649.
UP	13595-SALT LAKE CITY	UT	2684.
UP	13594-GARFIELD	UT	2696.
UP	16153-PFSF	UT	2781.

POPULATION DENSITY FROM: <C3> 96-MAINE YANKEE NP ME
TO: UP 16153-PFSF UT

		MILEAGE WITHIN DENSITY LEVELS											
St	Miles	0	<0.0 -5.0	5.0 -22.7	22.7 -59.7	59.7 -139	139 -326	326 -821	821 -1861	1861 -3326	3326 -5815	5815 -9996	>9996
CO	10.0	.4	6.6	.3	.4	.5	.6	1.2	.0	.0	.0	.0	.0
IL	150.9	7.8	11.3	24.1	20.5	12.5	10.7	10.7	10.3	8.5	10.4	11.1	13.0
IN	148.4	8.7	24.7	13.3	25.5	13.9	13.7	14.6	12.8	10.7	6.8	3.0	.6
IA	336.2	15.7	79.0	83.3	67.2	29.7	20.6	12.1	8.6	9.4	6.3	3.1	1.4
ME	100.9	17.6	3.2	4.4	5.1	10.6	37.1	16.7	3.7	1.0	.3	.2	.9
MA	151.0	2.6	3.8	5.5	29.0	15.5	29.9	26.4	22.5	6.4	4.1	2.2	3.2
NE	451.5	58.4	191.9	111.4	37.8	19.7	11.1	7.0	6.5	4.7	2.3	.7	.0
NH	31.4	1.1	.2	.6	1.5	4.2	10.4	6.7	5.3	1.1	.4	.0	.0
NY	460.4	45.8	37.1	44.6	100.3	99.0	57.7	30.3	21.8	12.2	5.8	3.7	2.1
OH	245.9	27.3	5.5	9.1	23.5	32.4	37.7	36.5	33.3	18.1	13.8	7.3	1.5
PA	44.0	1.0	1.3	.3	1.8	9.3	13.3	4.8	4.4	2.2	3.6	1.7	.4
UT	206.1	67.5	76.3	26.7	2.9	2.4	2.7	4.8	7.0	7.2	6.4	2.0	.2
VT	6.0	.0	.0	.0	.0	6.0	.0	.0	.0	.0	.0	.0	.0
WY	438.6	112.5	276.3	18.0	18.0	3.8	2.0	2.8	2.2	1.3	1.2	.4	.0

```
Totals
  2781.3366.4 717.3 341.8 333.5 259.5 247.3 174.5 138.4  82.6  61.3  35.3  23.3

Percentages
         13.2  25.8  12.3  12.0   9.3   8.9   6.3   5.0   3.0   2.2   1.3    .8
Basis: 1990 Census data

   RADTRAN Input Data      Rural Suburban    Urban

   Weighted Population
        People/sq. mi.      22.8    867.1   6609.1
        People/sq. km.       8.8    334.8   2551.8

   Distance                                      Total
        Miles             2018.4    642.8    120.0   2781.3
        Kilometers        3248.2   1034.5    193.1   4475.9
        Percentage          72.6     23.1      4.3

   Basis (people/sq. mi.)   <139 139-3326    >3326

   Note: Due to rounding, the sum of the mileages in the individual
         population categories may not equal the total mileage shown
         on this report.
```

C.8 Interline Output for the Route Between the Maine Yankee Nuclear Plant (in Maine) and Timpie, Utah

```
 INTERLINE 5.10  NETWORK 14.00

 ROUTE FROM:  <C3>    96-MAINE YANKEE NP     ME     LENGTH:  2727.3 MILES
         TO:  UP   13516-TIMPIE              UT  POTENTIAL:  3628.4


MILEAGE SUMMARY BY RAILROAD          A-M   B-M   A-BR  B-BR  OTHER
                      CPRS  352.7    209.8 142.9    .0    .0     .0
                      NS    528.9    521.9   7.0    .0    .0     .0
                      UP   1521.7   1509.9  11.8    .0    .0     .0
                      ST    293.0       .0 278.0    .0  15.0     .0
                      <C3>   31.0       .0    .0    .0  31.0     .0
                           -  -  -  -  -  -  -  -  -  -  -  -  -  -
                    TOTAL  2727.3   2241.6 439.7    .0  46.0     .0
 MILEAGE SUMMARY BY STATE
          10.0-CO    150.9-IL    148.4-IN    336.2-IA    100.9-ME
         151.0-MA    451.5-NE     31.4-NH    460.4-NY    245.9-OH
          44.0-PA    152.1-UT      6.0-VT    438.6-WY



   RR      NODE            STATE  DIST
  <C3>    96-MAINE YANKEE NP ME     0.
  <C3>   121-BRUNSWICK       ME    31.
 - - - - - - - - - - - - - - - - - - - - - - - - TRANSFER
  ST     121-BRUNSWICK       ME    31.
  ST     135-YARMOUTH JCT    ME    45.
  ST     132-PORTLAND        ME    61.
  ST     142-DOVER           NH   112.
  ST     291-LAWRENCE        MA   147.
  ST     299-LOWELL          MA   160.
  ST     423-AYER            MA   177.
  ST     432-FITCHBURG       MA   190.
  ST     447-MILLERS FALLS   MA   237.
  ST     454-GREENFIELD      MA   243.
  ST     694-MECHANICVILLE   NY   324.
 - - - - - - - - - - - - - - - - - - - - - - - - TRANSFER
  CPRS   694-MECHANICVILLE   NY   324.
  CPRS   706-SCHENECTADY     NY   337.
  CPRS  1037-BINGHAMTON      NY   467.
  CPRS  1039-WAVERLY         NY   507.
  CPRS  1008-ELMIRA          NY   525.
  CPRS  1009-CORNING         NY   543.
  CPRS   881-NIAGARA JCT     NY   665.
  CPRS   880-BUFFALO         NY   677.
 - - - - - - - - - - - - - - - - - - - - - - - - TRANSFER
  NS     880-BUFFALO         NY   677.
  NS     938-DUNKIRK         NY   718.
  NS     942-WESTFIELD       NY   742.
  NS     968-ERIE            PA   771.
  NS    2652-CONNEAUT        OH   795.
  NS    2649-ASHTABULA       OH   809.
  NS    2727-PAINESVILLE     OH   835.
  NS    2728-CLEVELAND       OH   865.
  NS    2633-ELYRIA          OH   892.
  NS   14985-OAK HARBOR      OH   949.
  NS    3442-TOLEDO          OH   971.
  NS    3526-GOSHEN          IN  1093.
  NS    3525-ELKHART         IN  1103.
  NS    4022-SOUTH BEND      IN  1118.
  NS    3969-LA PORTE        IN  1144.
```

NS	4067-PORTER	IN	1163.
NS	4069-MILLER	IN	1173.
NS	4070-GARY	IN	1178.
NS	4073-CLARKE	IN	1182.
NS	4074-INDIANA HARBOR	IN	1185.
NS	4035-WHITING LAKE FRO	IN	1188.
NS	4232-SOUTH CHICAGO	IL	1193.
NS	4217-CHICAGO	IL	1206.
- TRANSFER			
UP	4217-CHICAGO	IL	1206.
UP	4234-PROVISO	IL	1220.
UP	4214-WEST CHICAGO	IL	1235.
UP	4311-DE KALB	IL	1262.
UP	4324-NELSON	IL	1307.
UP	10304-CLINTON	IA	1342.
UP	10289-CEDAR RAPIDS	IA	1423.
UP	10265-MARSHALLTOWN	IA	1492.
UP	10246-NEVADA	IA	1519.
UP	10271-AMES	IA	1530.
UP	10177-ARION	IA	1628.
UP	10176-MISSOURI VALLEY	IA	1664.
UP	10198-CALIFORNIA JCT	IA	1670.
UP	11340-FREMONT	NE	1698.
UP	11473-CENTRAL CITY	NE	1785.
UP	11406-GRAND ISLAND	NE	1807.
UP	11410-GIBBON	NE	1833.
UP	11352-NORTH PLATTE	NE	1952.
UP	11358-O FALLONS	NE	1964.
UP	13703-JULESBURG	CO	2032.
UP	11287-SIDNEY	NE	2075.
UP	13465-CHEYENNE	WY	2178.
UP	13462-LARAMIE	WY	2230.
UP	13494-GRANGER	WY	2506.
UP	13568-OGDEN	UT	2649.
UP	13595-SALT LAKE CITY	UT	2684.
UP	13594-GARFIELD	UT	2696.
UP	13516-TIMPIE	UT	2727.

POPULATION DENSITY FROM: <C3> 96-MAINE YANKEE NP ME
TO: UP 13516-TIMPIE UT

------------------ MILEAGE WITHIN DENSITY LEVELS -------------------

St	Miles	0	<0.0 -5.0	5.0 -22.7	22.7 -59.7	59.7 -139	139 -326	326 -821	821 -1861	1861 -3326	3326 -5815	5815 -9996	>9996
CO	10.0	.4	6.6	.3	.4	.5	.6	1.2	.0	.0	.0	.0	.0
IL	150.9	7.8	11.3	24.1	20.5	12.5	10.7	10.7	10.3	8.5	10.4	11.1	13.0
IN	148.4	8.7	24.7	13.3	25.5	13.9	13.7	14.6	12.8	10.7	6.8	3.0	.6
IA	336.2	15.7	79.0	83.3	67.2	29.7	20.6	12.1	8.6	9.4	6.3	3.1	1.4
ME	100.9	17.6	3.2	4.4	5.1	10.6	37.1	16.7	3.7	1.0	.3	.2	.9
MA	151.0	2.6	3.8	5.5	29.0	15.5	29.9	26.4	22.5	6.4	4.1	2.2	3.2
NE	451.5	58.4	191.9	111.4	37.8	19.7	11.1	7.0	6.5	4.7	2.3	.7	.0
NH	31.4	1.1	.2	.6	1.5	4.2	10.4	6.7	5.3	1.1	.4	.0	.0
NY	460.4	45.8	37.1	44.6	100.3	99.0	57.7	30.3	21.8	12.2	5.8	3.7	2.1
OH	245.9	27.3	5.5	9.1	23.5	32.4	37.7	36.5	33.3	18.1	13.8	7.3	1.5
PA	44.0	1.0	1.3	.3	1.8	9.3	13.3	4.8	4.4	2.2	3.6	1.7	.4
UT	152.1	13.5	76.3	26.7	2.9	2.4	2.7	4.8	7.0	7.2	6.4	2.0	.2
VT	6.0	.0	.0	.0	.0	6.0	.0	.0	.0	.0	.0	.0	.0
WY	438.6	112.5	276.3	18.0	18.0	3.8	2.0	2.8	2.2	1.3	1.2	.4	.0

```
Totals
  2727.3312.4 717.3 341.8 333.5 259.5 247.3 174.5 138.4  82.6  61.3  35.3  23.3

Percentages
         11.5  26.3  12.5  12.2   9.5   9.1   6.4   5.1   3.0   2.2   1.3    .9
Basis: 1990 Census data

   RADTRAN Input Data      Rural Suburban    Urban

   Weighted Population
        People/sq. mi.      23.4    867.1   6609.1
        People/sq. km.       9.1    334.8   2551.8

   Distance                                       Total
        Miles            1964.4    642.8    120.0   2727.3
        Kilometers       3161.3   1034.5    193.1   4389.0
        Percentage         72.0     23.6      4.4

   Basis (people/sq. mi.)   <139 139-3326    >3326

   Note: Due to rounding, the sum of the mileages in the individual
         population categories may not equal the total mileage shown
         on this report.
```

C.9 Interline Output for the Route Between Timpie, Utah, and the PFSF Site

```
                                             HIGHWAY  3.4                             Page    1
********************************************************************************************

            TIMPIE            I80  X77  UT       to       PFSF                       UT

********************************************************************************************

                     Leaving :  1/28/99 at  9:44 MST Arriving:  1/28/99 at 10:19 MST
                     Total Road Time:  0:35          Total Miles:   26.0

       Route Type: C with 2 Driver(s)   Time Bias:   .70  Mile Bias:   .30  Toll Bias:  1.00

        The following constraints are in effect:
           Route avoids links prohibiting truck use
           Route avoids ferry crossings

        Mileage by Highway Sign Type:
                Interstate:     .0    U.S.:     .0  State:     .0   Turnpike:     .0
                    County:     .0   Local:   26.0  Other:     .0

        Mileage by Highway Lane Type:
              Limited Access Multilane:     .0  Limited Access Single Lane:     .0
                     Multilane Divided:     .0         Multilane Undivided:     .0
              Principal Highways:     .0   Through Highways:     .0   Other:   26.0

                                              State Mileage
                                              -------------
                                               UT     26.0
```

```
                                             HIGHWAY  3.4                             Page    2
********************************************************************************************

            TIMPIE            I80  X77  UT       to       PFSF                       UT

********************************************************************************************

          .0             TIMPIE           I80  X77  UT       .0   0:00   1/28/99 at  9:44
        26.0  LOCAL      PFSF                       UT     26.0   0:35   1/28/99 at 10:19
```

HIGHWAY 3.4 Page 3

****

TIMPIE I80 X77 UT to PFSF UT

****

		MILEAGE WITHIN DENSITY LEVELS							
			<0.0	5.0	22.7	59.7	139	326	
State	Miles	0	-5.0	-22.7	-59.7	-139	-326	-821	>821
UT	26.0	7.9	14.2	3.9	.0	.0	.0	.0	.0
Route Total	26.0	7.9	14.2	3.9	.0	.0	.0	.0	.0
Percentages		30.2	54.7	15.1	.0	.0	.0	.0	.0

Basis: 1990 Census

RADTRAN Input Data	Rural	Suburban	Urban	
Weighted Population				
People/sq. mi.	3.5	.0	.0	
People/sq. km.	1.3	.0	.0	
Distance				Total
Miles	26.0	.0	.0	26.0
Kilometers	41.8	.0	.0	41.8
Percentage	100.0	.0	.0	
Basis (people/sq. mi.)	<139	139-3326	>3326	1990 Census

Note: Due to rounding, the sum of the mileages in the individual population categories may not equal the total mileage shown on this report.

C.10 Interline Output for the Route Between Skull Valley, Utah, and the Utah-Nevada Border

```
   INTERLINE 5.10  NETWORK 14.00

   ROUTE FROM:  UP   16153-PFSF                 UT     LENGTH:   353.7 MILES
           TO:  UP   13615-UVADA                UT  POTENTIAL:  359.96


  MILEAGE SUMMARY BY RAILROAD           A-M   B-M   A-BR  B-BR  OTHER
                      UP    353.7    321.7    .0    .0  32.0     .0
                          - - - - - - - - - - - - - - - - - - - - - -
                    TOTAL   353.7    321.7    .0    .0  32.0     .0
   MILEAGE SUMMARY BY STATE
           353.7-UT



     RR      NODE            STATE  DIST
    UP   16153-PFSF            UT     0.
    UP   13594-GARFIELD        UT    85.
    UP   13630-LYNNDYL         UT   188.
    UP   13615-UVADA           UT   354.



   POPULATION DENSITY FROM:  UP   16153-PFSF                UT
                        TO:  UP   13615-UVADA               UT

         ------------------  MILEAGE WITHIN DENSITY LEVELS  -------------------
               <0.0   5.0  22.7  59.7   139   326   821  1861  3326  5815
St Miles    0  -5.0 -22.7 -59.7  -139  -326  -821 -1861 -3326 -5815 -9996 >9996
--------------------------------------------------------------------------------

UT 353.7112.5 203.5  27.5   4.6   2.2    .9    .7   1.4    .5    .0    .0    .0

Totals
   353.7112.5 203.5  27.5   4.6   2.2    .9    .7   1.4    .5    .0    .0    .0
Percentages
         31.8  57.5   7.8   1.3    .6    .2    .2    .4    .1    .0    .0    .0
Basis: 1990 Census data

   RADTRAN Input Data      Rural Suburban    Urban

   Weighted Population
        People/sq. mi.       3.7   1076.3       .0
        People/sq. km.       1.4    415.5       .0

   Distance                                         Total
        Miles              350.2      3.5       .0    353.7
        Kilometers         563.7      5.6       .0    569.2
        Percentage          99.0      1.0       .0

   Basis (people/sq. mi.)   <139 139-3326    >3326

   Note: Due to rounding, the sum of the mileages in the individual
         population categories may not equal the total mileage shown
         on this report.
```

C.11 Interline Output for the Route Between Timpie, Utah, and the Utah-Nevada Border

```
   INTERLINE 5.10  NETWORK 14.00

   ROUTE FROM:  UP   13516-TIMPIE              UT     LENGTH:   299.7 MILES
           TO:  UP   13615-UVADA               UT  POTENTIAL:  239.76


  MILEAGE SUMMARY BY RAILROAD           A-M   B-M   A-BR  B-BR  OTHER
                      UP    299.7    299.7    .0    .0    .0     .0
                           -  -  -  -  -  -  -  -  -  -  -  -  -  -
                    TOTAL   299.7    299.7    .0    .0    .0     .0
   MILEAGE SUMMARY BY STATE
           299.7-UT



     RR      NODE            STATE  DIST
    UP   13516-TIMPIE          UT     0.
    UP   13594-GARFIELD        UT    31.
    UP   13630-LYNNDYL         UT   134.
    UP   13615-UVADA           UT   300.



   POPULATION DENSITY FROM:  UP   13516-TIMPIE             UT
                       TO:  UP   13615-UVADA              UT

         ------------------  MILEAGE WITHIN DENSITY LEVELS  -------------------
               <0.0   5.0  22.7  59.7   139   326   821  1861  3326  5815
St Miles    0  -5.0 -22.7 -59.7  -139  -326  -821 -1861 -3326 -5815 -9996 >9996
--------------------------------------------------------------------------------

UT 299.7 58.5 203.5  27.5   4.6   2.2    .9    .7   1.4    .5    .0    .0    .0

Totals
   299.7 58.5 203.5  27.5   4.6   2.2    .9    .7   1.4    .5    .0    .0    .0
Percentages
         19.5  67.9   9.2   1.5    .7    .3    .2    .5    .2    .0    .0    .0
Basis: 1990 Census data

   RADTRAN Input Data      Rural Suburban    Urban

   Weighted Population
        People/sq. mi.       4.4   1076.3       .0
        People/sq. km.       1.7    415.5       .0

   Distance                                        Total
        Miles              296.2      3.5       .0    299.7
        Kilometers         476.8      5.6       .0    482.3
        Percentage          98.8      1.2       .0

   Basis (people/sq. mi.)   <139 139-3326    >3326

   Note: Due to rounding, the sum of the mileages in the individual
         population categories may not equal the total mileage shown
         on this report.
```

C.12 Interline Output for the Route Between the Maine Yankee Nuclear Plant and the Wyoming Site

```
 INTERLINE 5.10  NETWORK 14.00

 ROUTE FROM:  <C3>    96-MAINE YANKEE NP     ME     LENGTH:  2440.2 MILES
         TO:  BNSF 13499-BONNEVILLE          WY  POTENTIAL:  3372.5


MILEAGE SUMMARY BY RAILROAD          A-M   B-M   A-BR  B-BR  OTHER
                     BNSF 1225.9   1061.5 164.4    .0    .0     .0
                     CPRS  352.7    209.8 142.9    .0    .0     .0
                     NS    517.6    517.6    .0    .0    .0     .0
                     IHB    20.0     20.0    .0    .0    .0     .0
                     ST    293.0       .0 278.0    .0  15.0     .0
                     <C3>   31.0       .0    .0    .0  31.0     .0
                          -  -  -  -  -  -  -  -  -  -  -  -  -  -
                   TOTAL  2440.2   1808.9 585.3    .0  46.0     .0
 MILEAGE SUMMARY BY STATE
         203.5-IL    148.7-IN    286.0-IA    100.9-ME    151.0-MA
         512.0-NE     31.4-NH    460.4-NY    245.9-OH     44.0-PA
           6.0-VT    250.4-WY



   RR      NODE            STATE  DIST
  <C3>    96-MAINE YANKEE NP ME     0.
  <C3>   121-BRUNSWICK       ME    31.
 - - - - - - - - - - - - - - - - - - - - - - - - - TRANSFER
  ST     121-BRUNSWICK       ME    31.
  ST     135-YARMOUTH JCT    ME    45.
  ST     132-PORTLAND        ME    61.
  ST     142-DOVER           NH   112.
  ST     291-LAWRENCE        MA   147.
  ST     299-LOWELL          MA   160.
  ST     423-AYER            MA   177.
  ST     432-FITCHBURG       MA   190.
  ST     447-MILLERS FALLS   MA   237.
  ST     454-GREENFIELD      MA   243.
  ST     694-MECHANICVILLE   NY   324.
 - - - - - - - - - - - - - - - - - - - - - - - - - TRANSFER
  CPRS   694-MECHANICVILLE   NY   324.
  CPRS   706-SCHENECTADY     NY   337.
  CPRS  1037-BINGHAMTON      NY   467.
  CPRS  1039-WAVERLY         NY   507.
  CPRS  1008-ELMIRA          NY   525.
  CPRS  1009-CORNING         NY   543.
  CPRS   881-NIAGARA JCT     NY   665.
  CPRS   880-BUFFALO         NY   677.
 - - - - - - - - - - - - - - - - - - - - - - - - - TRANSFER
  NS     880-BUFFALO         NY   677.
  NS     938-DUNKIRK         NY   718.
  NS     942-WESTFIELD       NY   742.
  NS     968-ERIE            PA   771.
  NS    2652-CONNEAUT        OH   795.
  NS    2649-ASHTABULA       OH   809.
  NS    2727-PAINESVILLE     OH   835.
  NS    2728-CLEVELAND       OH   865.
  NS    2633-ELYRIA          OH   892.
  NS   14985-OAK HARBOR      OH   949.
  NS    3442-TOLEDO          OH   971.
  NS    3526-GOSHEN          IN  1093.
  NS    3525-ELKHART         IN  1103.
  NS    4022-SOUTH BEND      IN  1118.
```

```
    NS    3969-LA PORTE        IN  1144.
    NS    4067-PORTER          IN  1163.
    NS    4069-MILLER          IN  1173.
    NS    4070-GARY            IN  1178.
    NS    4073-CLARKE          IN  1182.
    NS    4075-EAST CHICAGO    IN  1185.
    NS    4076-HAMMOND         IN  1188.
    NS    4228-BURNHAM / CALUMEIL  1190.
    NS    4223-DOLTON / RIVERDAIL  1194.
   - - - - - - - - - - - - - - - - - - - - - - - - TRANSFER
    IHB   4223-DOLTON / RIVERDAIL  1194.
    IHB   4163-BLUE ISLAND     IL  1198.
    IHB   4164-CHICAGO RIDGE   IL  1204.
    IHB   4172-ARGO            IL  1210.
    IHB   4170-LA GRANGE       IL  1214.
   - - - - - - - - - - - - - - - - - - - - - - - - TRANSFER
    BNSF  4170-LA GRANGE       IL  1214.
    BNSF  4190-AURORA          IL  1239.
    BNSF  4478-GALESBURG       IL  1359.
    BNSF 10381-BURLINGTON      IA  1401.
    BNSF 10373-OTTUMWA         IA  1476.
    BNSF 10367-ALBIA           IA  1499.
    BNSF 10443-CRESTON         IA  1592.
    BNSF 10435-PACIFIC JCT     IA  1674.
    BNSF 11537-OREAPOLIS       NE  1683.
    BNSF 11470-ASHLAND         NE  1708.
    BNSF 11504-LINCOLN         NE  1731.
    BNSF 11475-AURORA          NE  1808.
    BNSF 11406-GRAND ISLAND    NE  1826.
    BNSF 11289-ALLIANCE        NE  2101.
    BNSF 11288-NORTHPORT       NE  2136.
    BNSF 13470-GUERNSEY        WY  2231.
    BNSF 13474-CASPER          WY  2340.
    BNSF 13499-BONNEVILLE      WY  2440.


   POPULATION DENSITY FROM:  <C3>    96-MAINE YANKEE NP     ME
                       TO:  BNSF 13499-BONNEVILLE          WY
```

MILEAGE WITHIN DENSITY LEVELS

St	Miles	0	<0.0 -5.0	5.0 -22.7	22.7 -59.7	59.7 -139	139 -326	326 -821	821 -1861	1861 -3326	3326 -5815	5815 -9996	>9996
IL	203.5	14.1	41.1	42.0	26.5	15.4	9.1	8.3	11.9	12.5	14.6	6.1	2.0
IN	148.7	8.2	24.9	13.5	25.3	13.5	13.7	14.5	12.4	11.1	7.7	2.9	1.0
IA	286.0	12.5	87.0	110.0	25.0	14.4	7.7	8.0	9.9	7.1	3.7	.6	.0
ME	100.9	17.6	3.2	4.4	5.1	10.6	37.1	16.7	3.7	1.0	.3	.2	.9
MA	151.0	2.6	3.8	5.5	29.0	15.5	29.9	26.4	22.5	6.4	4.1	2.2	3.2
NE	512.0	20.0	265.2	120.8	46.6	21.1	13.0	8.7	7.4	3.5	3.3	2.0	.5
NH	31.4	1.1	.2	.6	1.5	4.2	10.4	6.7	5.3	1.1	.4	.0	.0
NY	460.4	45.8	37.1	44.6	100.3	99.0	57.7	30.3	21.8	12.2	5.8	3.7	2.1
OH	245.9	27.3	5.5	9.1	23.5	32.4	37.7	36.5	33.3	18.1	13.8	7.3	1.5
PA	44.0	1.0	1.3	.3	1.8	9.3	13.3	4.8	4.4	2.2	3.6	1.7	.4
VT	6.0	.0	.0	.0	.0	6.0	.0	.0	.0	.0	.0	.0	.0
WY	250.4	41.1	163.6	21.9	6.4	3.5	4.7	4.3	1.4	.7	1.2	1.3	.2
Totals	2440.2	191.2	632.8	372.8	291.0	244.9	234.1	165.1	134.1	75.7	58.4	28.0	11.7
Percentages		7.8	25.9	15.3	11.9	10.0	9.6	6.8	5.5	3.1	2.4	1.1	.5

Basis: 1990 Census data

RADTRAN Input Data   Rural Suburban   Urban

Weighted Population				
People/sq. mi.	24.9	862.6	6170.9	
People/sq. km.	9.6	333.0	2382.6	
Distance				Total
Miles	1732.8	609.0	98.2	2440.2
Kilometers	2788.5	980.1	158.0	3927.0
Percentage	71.0	25.0	4.0	
Basis (people/sq. mi.)	<139	139-3326	>3326	

Note: Due to rounding, the sum of the mileages in the individual population categories may not equal the total mileage shown on this report.

C.13 Interline Output for the Route Between the Wyoming Site and the Utah-Nevada Border

```
    INTERLINE 5.10  NETWORK 14.00

    ROUTE FROM:  BNSF 13499-BONNEVILLE          WY     LENGTH:  1110.8 MILES
            TO:  UP   13615-UVADA               UT  POTENTIAL:  1391.9

   MILEAGE SUMMARY BY RAILROAD          A-M   B-M   A-BR  B-BR  OTHER
                         BNSF  323.4     37.0 286.4    .0    .0     .0
                         UP    787.4    787.4    .0    .0    .0     .0
                              - - - -  - - - - - -  - - - - - - -
                       TOTAL  1110.8    824.4 286.4    .0    .0     .0
    MILEAGE SUMMARY BY STATE
            389.8-UT    721.0-WY

      RR      NODE            STATE  DIST
     BNSF 13499-BONNEVILLE      WY     0.
     BNSF 13474-CASPER          WY   100.
     BNSF 13465-CHEYENNE        WY   323.
    - - - - - - - - - - - - - - - - - - - - - - - TRANSFER
     UP   13465-CHEYENNE        WY   323.
     UP   13462-LARAMIE         WY   375.
     UP   13494-GRANGER         WY   651.
     UP   13568-OGDEN           UT   795.
     UP   13595-SALT LAKE CITY  UT   830.
     UP   13594-GARFIELD        UT   842.
     UP   13630-LYNNDYL         UT   945.
     UP   13615-UVADA           UT  1111.


    POPULATION DENSITY FROM:  BNSF 13499-BONNEVILLE          WY
                         TO:  UP   13615-UVADA               UT

          ------------------  MILEAGE WITHIN DENSITY LEVELS  -------------------
                <0.0   5.0  22.7  59.7   139   326   821  1861  3326  5815
 St Miles    0  -5.0 -22.7 -59.7  -139  -326  -821 -1861 -3326 -5815 -9996 >9996
 -------------------------------------------------------------------------------

 UT 389.8 56.4 240.5  47.0   7.5   4.6   3.5   5.5   8.4   7.6   6.4   2.0    .2
 WY 721.0142.9 483.1  43.9  23.1   6.9   5.7   6.7   4.2   1.2   1.5   1.5    .2

 Totals
   1110.8199.4 723.7  90.9  30.6  11.5   9.2  12.3  12.6   8.8   8.0   3.5    .4
 Percentages
          17.9  65.1   8.2   2.8   1.0    .8   1.1   1.1    .8    .7    .3    .0
 Basis: 1990 Census data

    RADTRAN Input Data      Rural Suburban    Urban

    Weighted Population
         People/sq. mi.       5.2   1141.9   5724.0
         People/sq. km.       2.0    440.9   2210.1

    Distance                                      Total
         Miles             1056.0     42.9     11.8   1110.8
         Kilometers        1699.5     69.1     19.0   1787.6
         Percentage          95.1      3.9      1.1

    Basis (people/sq. mi.)   <139 139-3326    >3326

    Note: Due to rounding, the sum of the mileages in the individual
          population categories may not equal the total mileage shown
          on this report.
```

C.14 References

Johnson, P. E., et al. 1993. *INTERLINE 5.0, An Expanded Railroad Routing Model: Program Description, Methodology, and Revised Users Manual*, ORNL/TM-12090, Oak Ridge National Laboratory, Oak Ridge, Tenn.

APPENDIX D

TRANSPORTATION RISK ANALYSIS

To supplement the less-detailed discussions in Chapter 5, this appendix contains: (1) a description of RADTRAN4 and the major assumptions used in estimating the doses for the cross-country (i.e., from reactor sites to PFSF) and regional (i.e., within the State of Utah) analyses; (2) a summary of NUREG-0170 (NRC 1977); (3) an analysis of the regional transportation risks for Utah; and (4) an analysis of the regional transportation risk for the alternative site in Wyoming.

D.1 The RADTRAN4 Computer Code

As part of the analysis of potential impacts in this FEIS, a transportation risk assessment was performed using the INTERLINE routing code (see Appendix C) and the RADTRAN4 risk assessment code. This section describes the RADTRAN4 computer code and how it was used in the assessment of incident-free transportation conditions and accident scenarios

D.1.1 The RADTRAN4 Incident-Free Model

The RADTRAN4 calculations for generating estimates of the incident-free transportation dose to the public are based on expressing the dose rate as a function distance of from a point source (Neuhauser and Kanipe 1993). RADTRAN4 estimates doses to the number of persons expected to be exposed to the SNF shipment and calculates an overall risk to the public based on the total dose. Associated with the calculation of the incident-free doses for each exposed population group are parameters such as the radiation field strength, source-receptor distance, duration of exposure, vehicular speed, traffic density, and route characteristics (such as population density). The RADTRAN4 manual contains derivations of the equations and descriptions of these parameters (Neuhauser and Kanipe 1993).

The RADTRAN4 code calculates the dose to the public in an area that runs along the rail line and extends perpendicular from both sides of the track to a distance from 30 m to 800 m (98 ft to 0.5 mile). Added to this computed dose are the collective doses for persons that share the transportation route (e.g., oncoming passenger trains passing on parallel tracks). The dose (in mrem) received by each person in that defined area is a function of the dose rate (in mrem/hr) at 1 m from the cask surface, the distance that person is from the track, and the speed of the train as it passes by. The RADTRAN4 manual contains the derivations of the equations and descriptions of the parameters used in the code (Neuhauser and Kanipe 1993).

The radiation field that surrounds the cask decreases markedly as the distance from the cask increases. At distances from 30 m to 800 m (98 ft to 0.5 mile), the cask will appear almost like a point source and therefore, the dose rate will decrease as the square of the distance from the cask. Figure D.1 illustrates the approximate dose rate as a function of distance from a cask that reads 0.13 mSv/hr (13 mrem/hr) at 1 m (3 ft) from its surface, assuming the radiation field exists in a vacuum (e.g., there would be no buildup nor attenuation of the gamma rays in air). In this FEIS, each

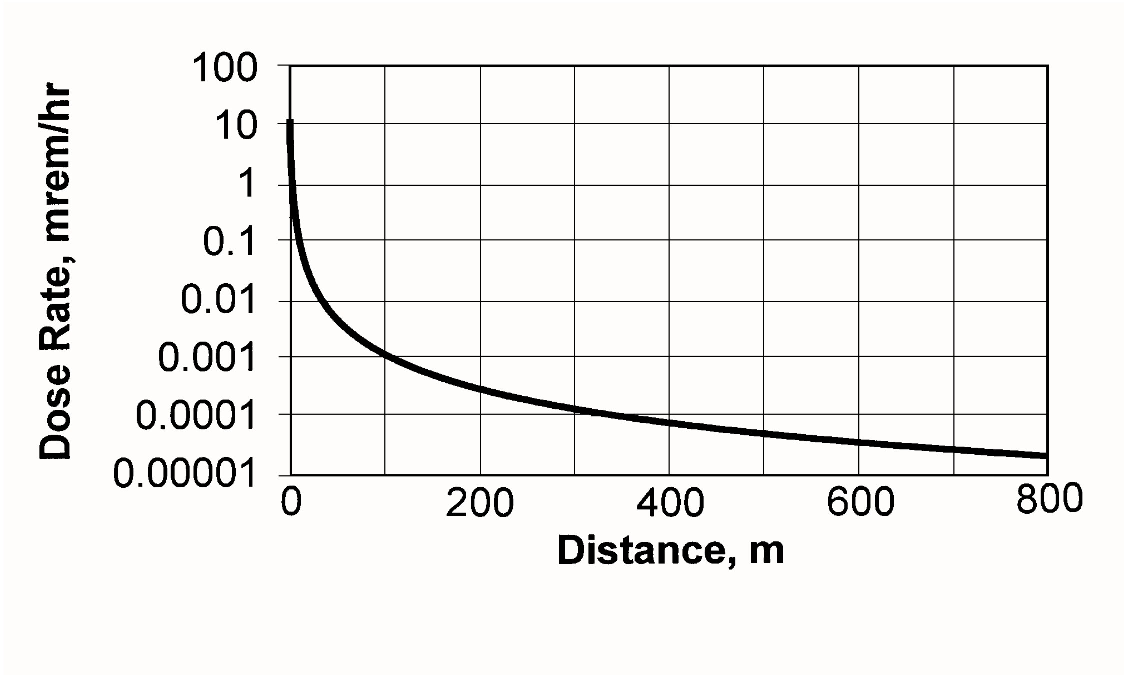

Figure D.1. Estimated dose rate as a function of distance from a cask reading 0.13 mSv/hr (13 mrem/hr) at 1 m (3 ft) from its surface.

cask was assumed to have a dose rate of 0.13 mSv/hr at a distance of 1 m (13 mrem/hr at 3 ft) from the cask surface, which is equivalent to the regulatory limit of 0.1 mSv/hr at 2 m (10 mrem/hr at 6.5 ft). Both point-source and line-source approximations were used based upon the distance between the exposed individuals and the radiation source. The source term was conservatively assumed to consist entirely of gamma radiation for calculation of the incident-free dose. Actual cask radiation levels are measured prior to each shipment and in practice are expected to be lower than the regulatory limit.

Note that to estimate the dose received by a person at a specific distance from the track, the dose rate and exposure time at that distance are accounted for. In general, exposure time is expected to be only a few minutes as the train passes by (depending on the train speed). Given the population density along various parts of the route, RADTRAN4 integrates the exposure of all persons at all distances from the track out to the maximum distance from the rail line. That product is multiplied by the population density to determine the collective dose to the population along a specific route.

Radiation doses to the population and workers were converted to estimates of LCFs using the upper limit risk coefficient suggested by the National Academy of Sciences (NAS) (ICRP 1991; NAS 1990). The NAS report, commonly called the “BEIR V report,” gives statistics on the number of cancer deaths expected to occur from a continuous exposure of 1 rem/year above background from age 18 until age 65. This value results in a risk factor of 4.0×10^{-6} LCFs per person-Sv (4.0×10^{-4} LCFs per person-rem) that is more applicable to occupational exposures. The BEIR V report also considers the number of cancer deaths expected to occur from a continuous lifetime exposure of 0.001 Sv/yr (0.1 rem/yr) above background which results in a risk factor of 5×10^{-6} LCFs per person-Sv (5.0×10^{-4} LCFs per person-rem) that is more applicable to exposures of the general public. Note that even though the assumed general public exposure is less than the assumed occupational exposure, the general public LCF risk factor is slightly higher. This is because the general public dose is assumed to occur over an entire lifetime as opposed to the occupational work period (e.g., 8-hr day shift) from age

18 until age 65. Both of these risk factors were used in this study depending upon whether the exposures were occupational or general population exposures.

D.1.2 Population Assumptions for Incident-Free transport

The RADTRAN4 calculations of risk for incident-free rail transportation include exposures of the following population groups:

- *Persons along the Route (Off-Link Population)*. Collective doses are calculated for all persons living or working within 0.8 km (0.5 miles) on each side of the transportation route. The total number of persons within this 1.6-km (1-mile) corridor is calculated separately for each route considered in the assessment.
- *Persons sharing the Route (On-Link Population)*. Collective doses are calculated for persons in all vehicles sharing the transportation route. This group includes persons traveling in the same or the opposite direction as the shipment, as well as persons in the vehicles passing the shipment.
- *Persons at Stops.* Collective doses are normally calculated for people who may be exposed while a shipment is stopped en route. The distance of each route analyzed for the regional transportation analysis was relatively short [i.e., approximately 400 km (250 miles)]; therefore, no rail stops were assumed. For the cross-country analysis a minimum of two stops were assumed.
- *Crew Members.* Collective doses are calculated for rail crew members according to the method described in the RADTRAN 4 technical manual.

The doses calculated by RADTRAN4 for the first three population groups are added to yield the collective dose to the public. The dose calculated for the fourth group represents the dose to workers (in this case the crew members, inspectors, and rail yard workers). This is added to the dose received by ITF workers (for the alternatives where an ITF would be utilized) to yield the total collective worker dose.

In the RADTRAN4 calculations performed for this FEIS, three population density zones (rural, suburban, and urban) were used to compute the risk between the origin-and-destination pairs of every rail route which ended at either the PFSF site in Utah or the alternative candidate site in Wyoming. The fractions of travel in each zone were determined by using the INTERLINE (rail) routing model (Johnson, et. al. 1993) as described in Appendix C of this FEIS. The routing model identified the specific population densities in each zone along each route based on the 1990 census data. Population density information in each of the three population density zones is based on an aggregation of the twelve population density zones provided in the INTERLINE output and is compatible with the RADTRAN4 code.

D.1.3 Risks During Incident-Free Transportation

The results of the RADTRAN4 computer runs are displayed in Chapters 5 and 7 of this FEIS for the cross-country analysis. A brief summary of the regional transportation analysis is also included there. Sections D.3 and D.4 in this appendix present more detailed results of the regional transportation analysis. The output includes dose calculations for the public and the workers. These dose calculations have been converted into LCFs by the use of appropriate conversion factors. Numerical values for doses and LCFs appear in Chapters 5 and 7 of this FEIS as well as Sections D.3 and D.4 in this appendix.

D.1.4 Transportation Accident Risks

RADTRAN4 was used to compute the doses to the public in the event of an accident that releases radioactive materials to the environment. The RADTRAN4 calculations performed for this FEIS used a cask inventory calculated using the ORIGEN Code (Croff 1980) and severity and release fractions taken from the Modal Study (Fischer 1987). A release fraction is the fraction of the radioactive material in the spent fuel cask that could be released from that cask during an accident of a certain severity. The severity fraction is the fraction of all accidents that are of a specified severity, i.e., fall within a range of accident conditions produced by specified collision forces and fire temperatures. Release fractions take into account both the fraction of the spent fuel rods in the cask that fail and also all mechanisms necessary to cause the release of radioactive material from a failed fuel rod into a damaged shipping cask and then from the damaged cask into the environment. Release fractions vary according to the shipping cask type and the physical form of the radioactive materials released from the cask (i.e., particulate, volatile solid, gas).

In the case of SNF, there would be some solids, gases, and volatile materials that could be released in the event that spent fuel rods fail and the cask seal is breached in a severe accident. Some of the radioactive gases that are generated in the fuel pellets, and that had diffused and collected in the helium gas plenum of each spent fuel rod, would be released to the cask cavity from each fuel rod that is ruptured in an accident. Volatile gases generally require heat to cause them to diffuse into the gas plenum and remain in a gaseous form. Particulates would come from fuel pellets, some of which could be crushed, producing fines, a powder-like material. The fines would be carried out of the failed rod into the cask cavity by the depressurization flow of helium gas. Once this powdery material and the gases are freed into the cask cavity, if the cask is breached some fraction of that material could be released from the cask to the environment. The most likely breach in a shipping cask would be caused by a seal that failed in the accident, opening a small leak path from the cask cavity to the environment.

CRUD is a colloquial term for corrosion and wear products (rust particles, etc.) that become radioactive (i.e., activated) when exposed to radiation in the reactor vessel. The term is popularly considered to be an acronym for Chalk River Unidentified Deposits, as Chalk River is the Canadian plant at which the activated deposits were first discovered. CRUD can plate out on hot surfaces in the primary reactor coolant system such as fuel rods. Activation of nickel in the corrosion products produces Co-60 which, after 5 years cooling time out of a reactor, is the only constituent in CRUD that is significant for transportation risk assessment. This FEIS accounts for the presence of CRUD, and its decay, in its inventory quantity for Co-60 for 5 year cooled fuel (5.23×10^2 Ci, see Table D.3). In order for CRUD particles to be released to the environment, there would need to be a break in the cask confinement boundary and a sufficient internal energy to dislodge, move, and emit them outside the cask.

D.1.4.1 Radionuclide Inventory

Each cask is assumed to contain 24 spent PWR fuel assemblies. The radionuclide inventory in the cask for the proposed SNF shipments to and from the PFSF and which was used in the RADTRAN4 calculations is given in Table D.1. All spent fuel shipped to the PFS site was assumed to have an average burnup of 40,000 MWD/MTU and to have cooled for five years. Activation products, actinides, and fission products were all identified and those elements whose activities exceeded about 1 percent of the total are listed in Table D.1.

Table D.1 Radionuclide inventory for the proposed SNF shipments

Isotope	Ci/shipping canister - 5 years cooled	Ci/shipping canister - 20 years cooled	Physical/chemical group	Dispensability category
Cobalt-60 (CRUD only)	5.23×10^{2}	7.27×10^{1}	particulates/CRUD	6
Krypton-85	9.07×10^{4}	3.43×10^{4}	gas	10
Strontium-90	8.86×10^{5}	6.19×10^{5}	volatile	7
Ruthenium-106	1.84×10^{5}	6.07×10^{0}	volatile	7
Cesium-134	4.20×10^{5}	2.71×10^{3}	volatile	7
Cesium-137	1.23×10^{6}	8.66×10^{5}	volatile	7
Promethium-147	4.06×10^{5}	7.70×10^{3}	particulates	2
Samarium-151	5.35×10^{3}	4.78×10^{3}	particulates	2
Europium-154	8.76×10^{4}	2.62×10^{4}	particulates	2
Plutonium-238	4.37×10^{4}	3.89×10^{4}	particulates	2
Plutonium-239	4.34×10^{3}	4.34×10^{3}	particulates	2
Plutonium-240	6.19×10^{3}	6.22×10^{3}	particulates	2
Plutonium-241	1.25×10^{6}	6.10×10^{5}	particulates	2
Americium-241	1.34×10^{4}	3.43×10^{4}	particulates	2
Americium-243	2.35×10^{2}	2.38×10^{2}	particulates	2
Curium-242	4.54×10^{2}	2.03×10^{2}	particulates	2
Curium-244	2.74×10^{4}	1.54×10^{4}	particulates	2
Total activity	$\mathbf{4.65 \times 10^{6}}$	$\mathbf{2.27 \times 10^{6}}$		

The dispensability categories shown in Table D.1 are used in RADTRAN to characterize the relative dispensability in the environment of each radionuclide assigned to the category if it escapes from the cask. RADTRAN4 uses the dispensability category to determine the fraction of a radionuclide's inventory that is aerosolized and the fraction of the aerosolized material that is respirable. RADTRAN4 contains default values for the aerosolized and respirable fractions of the total inventory that are keyed to the assigned dispersibility categories. Normally, the assignment of dispersibility categories to radionuclides by the RADTRAN4 user causes these default values to be used. However, because the release fractions in Table D.2 below already account for these aerosolized and respirable fractions, the default values in the RADTRAN4 input were all reset to values of 1.0.

D.1.4.2 Modal Study Accident Matrix

The analyses performed for the Modal Study (Fischer, 1987) developed: (1) a rail accident event tree, (2) the probability that each scenario on that tree involved a fire, (3) distributions of fire duration, fire temperature, fire location, accident speed, cask orientation at impact, and cask impact angle, and (4) equations that expressed the dependence of cask inner shell strain on cask impact parameters. Table 5.11 in the Modal Study specifies how these results were used to determine the probabilities that accidents would fall into one of the twenty bins in the 4 x 5 accident matrix (y-axis bin boundaries specified in terms of cask inner shell strain, x-axis bin boundaries specified in terms of lead mid-thickness temperature), and bin indices that have the form (y,x). Figure D.2 presents this 20 bin matrix and gives the index number for each bin and the conditional probability (conditional on the occurrence of some accident of any severity) that a vehicle accident will cause a spent fuel cask to experience the mechanical and thermal loads that fall within each bin. In this figure, the six accident categories for which different release fractions were developed in the Modal Study are outlined by heavy black borders.

D.1.4.3 Modal Study Release Fractions

To complete the development of accident source terms, a set of release fractions has to be associated with each accident bin in the 20-bin accident matrix depicted in Figure D.2. For the Modal Study, release fractions ($f_{release}$) were calculated using the following equation

$$f_{release} = (f_{rod})(f_{rod\text{-}to\text{-}cask})(f_{cask\text{-}to\text{-}environment}) \qquad \text{(Eq. D.1)}$$

where f_{rod} is the fraction of the spent fuel rods in the spent fuel cask that would be failed under the specified bin conditions, $f_{rod\text{-}to\text{-}cask}$ is the fraction of each radionuclide that would be released from the failed rods into the interior of the cask, and $f_{cask\text{-}to\text{-}environment}$ is the fraction of the amount of each radionuclide that was released into the cask that would escape from the cask through the cask leak to the environment. Because deposition of particles and condensation of vapors onto cask interior surfaces was conservatively neglected in the Modal Study analysis, $f_{cask\text{-}to\text{-}environment} = 1.0$, and Eq. D.1 reduces to

$$f_{release} = (f_{rod})(f_{rod\text{-}to\text{-}cask}) \qquad \text{(Eq. D.2)}$$

To simplify the analysis, values for $f_{rod\text{-}to\text{-}cask}$ were developed for three classes of radionuclide species: non-condensible gases, condensible gases (vapors), and particles (aerosols). Only one element, Krypton (Kr), was assigned to the non-condensible gas class; three elements, iodine (I), cesium (Cs), and ruthenium (Ru), were assigned to the condensible gas class; and all other elements were assumed to transport as constituents of particles and were thus assigned to the particles class.

In the Modal Study, values for f_{rod} were determined as follows. Cask inner shell strains less than 0.2 percent were assumed to fail 3 percent of the rods in the cask ($f_{rod} = 0.03$), strains between 0.2 and 2 percent were assumed to fail 10 percent of the rods in the cask ($f_{rod} = 0.1$), and strains greater than 2 percent were assumed to fail 100 percent of the rods in the cask ($f_{rod} = 1.0$). Any unfailed rod that is heated to temperatures over 650°F was assumed to fail by burst rupture.

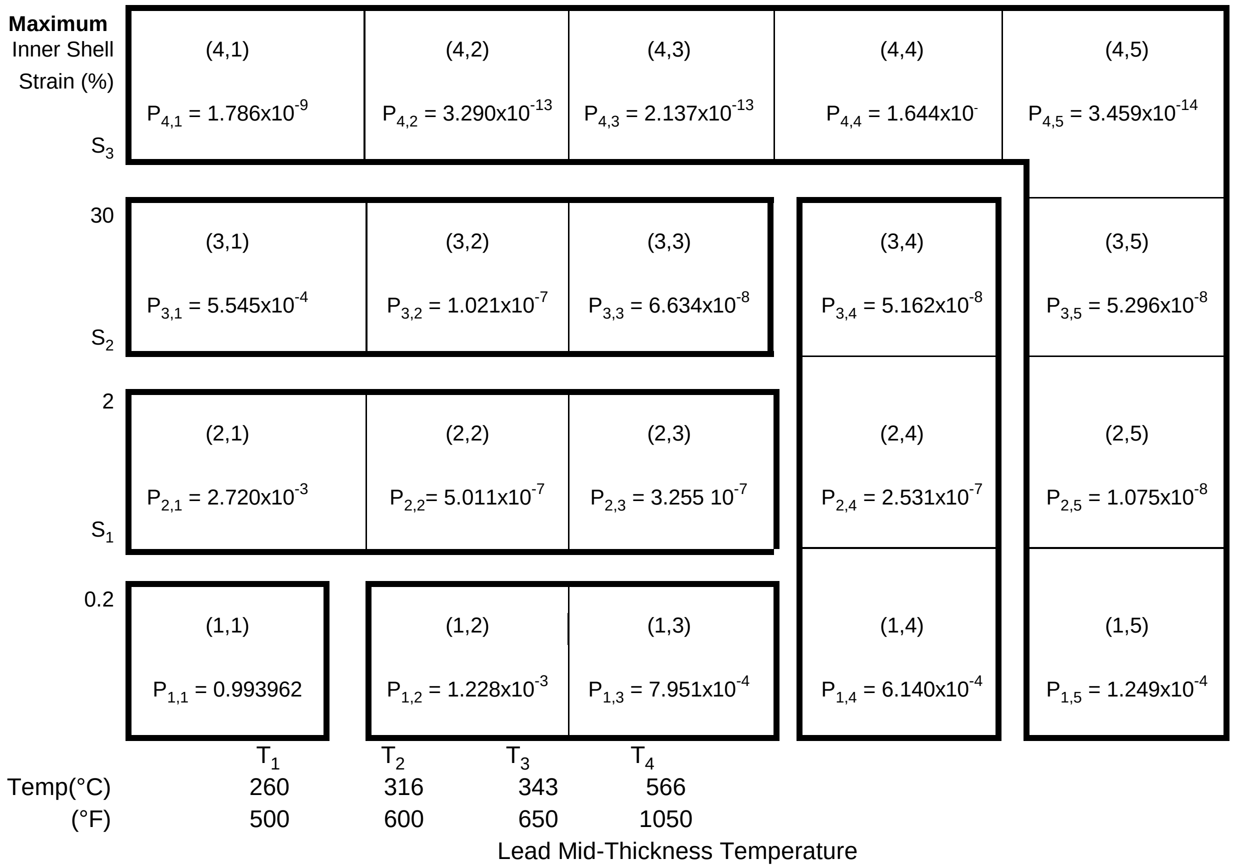

Figure D.2 Modal Study Accident Matrix

Modal Study rod-to-cask release fraction values were based on experimental studies (Lorentz 1980). Lorenz et al., examined the release of fission products from spent fuel rod sections when the rod sections were failed by burst rupture as a result of heating to elevated temperatures in steam or air atmospheres. Release by diffusion from rod sections, which had holes drilled through their cladding was also examined, but was found to be negligible when compared to the releases that occurred when rods failed by burst rupture. Rod section failure by burst rupture in air atmospheres was found to increase the release of I, Cs, and Ru. The increases were assumed to be caused by oxidation of uranium dioxide in fuel pellets which allowed iodine and cesium compounds to migrate more easily to the surface of the pellets and converted ruthenium from a relatively involatile oxide (RuO_2) to a significantly more volatile oxide (RuO_4). Review of the experimental results of Lorenz et al. led the Modal Study staff to define two sets of rod-to-cask release fractions. Each set was calculated as the sum of a release that occurs upon rod burst rupture and the release that occurs when the fuel is oxidized by exposure to air at temperatures above 400°F. Two sets of oxidative release fractions were selected, one for use below 650°F and the second for use between 650 and 1050°F. Table D.2 presents both of these sets of rod-to-cask release fractions.

Table D.2 Modal Study Rod-to-Cask Release Fractions

Release Fraction Set	Applicable Accident Matrix Bins	Release Mechanism	$f_{rod\text{-}to\text{-}cask}$				
			Gases	Vapors			Particles
			Kr	**I**	**Cs**	**Ru**	**All other elements**
1	(1,1) through (1,3) (2,1) through (2,3) (3,1) through (3,3)	Rod Burst	$2.0x10^{-1}$	$3.0x10^{-4}$	$2.0x10^{-4}$	$2.0x10^{-5}$	$2.0x10^{-6}$
		Oxidation	$1.3x10^{-1}$	$2.2x10^{-3}$	$1.0x10^{-6}$	$6.7x10^{-6}$	0
		Total	$3.3x10^{-1}$	$2.5x10^{-3}$	$2.0x10^{-4}$	$2.7x10^{-5}$	$2.0x10^{-6}$
2	(1,4) through (3,4)	Rod Burst	$2.0x10^{-1}$	$3.0x10^{-4}$	$2.0x10^{-4}$	$2.0x10^{-5}$	$2.0x10^{-6}$
		Oxidation	$1.9x10^{-1}$	$4.0x10^{-3}$	$8.0x10^{-6}$	$2.8x10^{-5}$	0
		Total	$3.9x10^{-1}$	$4.3x10^{-3}$	$2.0x10^{-4}$	$4.8x10^{-5}$	$2.0x10^{-6}$

Release fractions for accident matrix bins (4,1) through (4,5) and (1,5) through (3,5), the bins at the top and the far right of the matrix depicted in Figure D.2, were calculated by multiplying the total values for $f_{rod\text{-}to\text{-}cask}$ by 10 for I, Cs, Ru, and particles and by 1.62 for Kr. Combining the rod failure fractions and the release fractions that apply to each accident bin develops five sets of release fractions. Moreover, because inner shell strains less than 0.2 percent and mid-lead layer temperatures less than 500°F were assumed not to cause the spent fuel cask to leak, by definition, accident matrix bin (1,1) had release fractions values of 0.0. These six accident category regions are depicted by heavy black borders and separate boxes in Figure D.2. Table D.3 presents the values of the severity fractions and release fractions that apply to each of these six accident categories and Table D.4 briefly describes the principal characteristics of the accidents that fall into each accident category.

The accident consequences and risks that were calculated using these severity and release fractions are presented in Chapter 5 of this FEIS. Accident severity levels progress from Category 1 to Category 6. Category 1 accidents occur frequently but are not severe enough to cause the spent fuel cask to leak. Category 6 represents the most severe accident scenarios, which would result in the largest releases of radioactive material. Accidents of this severity are very rare. The conservative estimate used here and in the Modal Study is that Category 6 accidents occur approximately 1 in every 10,000 rail accidents involving a radioactive waste shipment. On the basis of national accident statistics (Saricks and Kvitek 1994) for every 1.6 km (1 mile) of a loaded shipment, the probability per kilometer of an accident of this severity is 1.25×10^{-11}. For this EIS the estimated shipping distance for 4,000 casks is about 17.4 million kilometers (10.8 million miles), so no accident of such severity is expected to occur.

The fractional occurrences of accidents that occur on rural, suburban, and urban route segments is given in Table D.5 by the accident severity category. These values were taken from NUREG-0170. As Table D.5 shows, each population density zone was given the same distribution of accident frequencies within each of the six accident categories since information on the variation of accident frequency as a function of population density zones was not available. The values in Table D.5 are also included in Table D.3.

Table D.3. Spent fuel severity and release fractions used in this study to calculate accident consequences and risks

Accident Category	Bin Number	Severity Fraction	Release Fraction: Gases	Volatiles	Particulates
1	(1,1)	0.993962	0	0	0
2	(1,2), (1,3)	2.02×10^{-3}	9.9×10^{-3}	6.0×10^{-8}	6.0×10^{-8}
3	(2,1), (2,2), (2,3)	2.72×10^{-3}	3.3×10^{-2}	2.0×10^{-5}	2.0×10^{-7}
4	(3,1), (3,2), (3,3)	5.55×10^{-4}	3.3×10^{-1}	2.0×10^{-4}	2.0×10^{-6}
5	(1,4), (2,4), (3,4)	6.14×10^{-4}	3.9×10^{-1}	2.0×10^{-4}	2.0×10^{-6}
6	(4,1), (4,2), (4,3), (4,4), (4,5), (1,5), (2,5), (3,5)	1.25×10^{-4}	6.3×10^{-1}	2.0×10^{-3}	2.0×10^{-5}

Table D.4. Accident severity categories used in the analysis

Accident Severity Category	Description
Severity Category 1	Conditions do not exceed those for a Type B shipping cask; no release of contents
Severity Category 2	Collisions that fail 3 percent of the rods in the cask and/or fires that do not heat the cask to temperatures above 650°F
Severity Category 3	Collisions that fail 10 percent of the rods in the cask and/or fires that do not heat the cask to temperatures above 650°F
Severity Category 4	Collisions that fail 100 percent of the rods in the cask and/or fires that do not heat the cask to temperatures above 650°F
Severity Category 5	Collisions that fail 3 percent of the rods in the cask and also initiate fires that heat the cask to 650 to 1050°F
Severity Category 6	Collisions that fail 100 percent of the rods in the cask and/or fires that heat the cask to temperatures above 1050°F

Table D.5. Fraction of accident occurrences

Accident Severity Category	Accident Location		
	Rural	Suburban	Urban
1	$9.94x10^{-1}$	$9.94x10^{-1}$	$9.94x10^{-1}$
2	$2.02x10^{-3}$	$2.02x10^{-3}$	$2.02x10^{-3}$
3	$2.72x10^{-3}$	$2.72x10^{-3}$	$2.72x10^{-3}$
4	$5.55x10^{-4}$	$5.55x10^{-4}$	$5.55x10^{-4}$
5	$6.14x10^{-4}$	$6.14x10^{-4}$	$6.14x10^{-4}$
6	$1.25x10^{-4}$	$1.25x10^{-4}$	$1.25x10^{-4}$

Note that equation D.1, $f_{release} = (f_{rod})(f_{rod\text{-}to\text{-}cask})$, where $(f_{cask\text{-}to\ environment}) = 1.0$, does not account for the additional barrier that the cask has which should significantly impede the release of fission products from the cask in an accident. This barrier is the welded stainless steel canister that would contain the SNF and which would be lifted out of the cask as a single unit, and placed in storage at the PFSF. For this FEIS, this additional barrier provided by the canister was assumed not to exist. Thus, the potential release of fission products from this cask under accident scenarios discussed in this FEIS is considered very conservative.

D.1.4.4 CRUD

To determine if the assumption of using modal study release fractions for CRUD was appropriate, or if it results in an underestimate of the accident dose risk, the NRC staff further investigated this issue, as described below.

Following issuance of the DEIS, the NRC staff reviewed other available studies for estimates of the possible impacts of CRUD releases. The phenomena that would govern spallation of CRUD from spent fuel rod surfaces when subjected to accident loads, its transport through the spent fuel cask, and release to the environment, were examined in NUREG/CR-6672 (Sprung 1999). That examination suggests that CRUD release fractions of spent fuel, when transported in a rail cask, could range from 10^{-3} to 10^{-1} depending on the accident conditions and severity. In contrast, the FEIS release fraction for CRUD is lower, as the FEIS utilized the release fractions for particulates inside the fuel rods, which range from 6×10^{-8} to 2×10^{-5}.

To determine an absolute upper bond for the effects due to various CRUD release fractions, the Maine Yankee-to-PFSF RADTRAN rail calculation performed for this FEIS was repeated by using a 100 percent CRUD release, which bounds the assumption in NUREG/CR-6672. This repeat calculation produced a single shipment accident population dose risk (adjusted by a factor of 1.3 to account for future population) of 0.000806 person-Sv (0.0806 person-rem). This value can be compared to the single shipment accident population dose risk of 0.000236 person-Sv (0.0236 person-rem)[1] reported in FEIS Section 5.7.2.5. Thus, in this example, where all 523 Ci of Co-60 (i.e., all the CRUD) is assumed to be released for any category 2 through 6 accident, the accident population dose risk would increase by a factor of 3.4 (0.0806/0.0236). However, as shown in Table 5.7, the transportation accident population dose risk associated with the proposed PFSF is a small fraction of the values reported in NUREG-0170. If the dose risk for the transportation of SNF to the proposed PFSF in Table 5.7 is increased by a factor of 3.4 above the value shown in the DEIS, the resulting population dose risk would still be a small fraction of the NUREG-0170 value, and the FEIS conclusion that the accident population dose risk is small would be unchanged.

In reporting the results for this FEIS, the NRC staff considered the above information but has chosen, as the base-case, to retain its application of Modal Study release fractions for particulates to CRUD. There are several reasons for this decision. First, the NRC staff does not believe that 100 percent release of CRUD in any accident is physically possible because (1) much of the CRUD is chemically bonded or tightly adheres to the fuel rod surface, (2) a leak pathway large enough to allow 100 percent escape is not credible, (3) the particle size distribution of spalled crud would be expected to include larger particles that would settle out inside the cask or possibly plug leak paths, and (4) a driving force (i.e., pressure differential) does not exist that could enable a 100 percent release. Second, in performing the FEIS accident risk assessment, the NRC staff ignored (i.e., did not allow credit for) the presence of the welded canister of the HOLTEC HI-STAR system, which will in practice provide a significant additional barrier to the release of radioactive materials in transportation accidents. Third,

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[1]The value of 0.0236 person-rem is the single-cask result reported in FEIS Section 5.7.2.5. Assuming four casks per train, an additional factor of 3.58 could be applied to the 0.0236 value, and the 0.0806 value, to obtain a result that assumes four casks have releases (as explained in FEIS Section 5.7.2.5). An additional factor of 50 (the number of 4-cask trains per year) could be applied to each value to obtain annual impacts (annual impacts are presented on many of the tables in this FEIS). In all cases the ratio between the example case of 100 percent crud release, and the FEIS methodology, will remain 3.4.

Co-60 has a radioactive half-life of 5.27 years, and its radioactivity decreases quickly in relation to the radioactivity in the spent fuel pellets. Therefore, CRUD importance to transport accident risk declines as cooling time increases, whereas the FEIS maximized its importance by conservatively assuming that the fuel is cooled for only 5 years even though PFS has indicated the average cooling time of SNF expected to be shipped to PFSF is 20 years. Fourth, the CRUD surface concentration on fuel assemblies, of 140 $\mu Ci/cm^2$, was conservatively selected based on the upper value observed by measurements of CRUD on rod surfaces (Sandoval et. al. 1991). Finally, the NRC staff believes that the Modal Study release fractions provide adequate estimates for the purpose of this FEIS of the releases of important nuclides for a range of severe accidents (because, for example, these release fractions assume no retention in the cask). In light of the above, the NRC staff has concluded that revision of the FEIS treatment of CRUD is not necessary, and that the radionuclide inventories and release fractions chosen in the FEIS provide an adequate characterization of transportation accident risk assessment results and adequate perspective regarding the importance of CRUD to the characterization of those results.

D.1.5 Intermodal Transportation and Cask Transfer Operations

D.1.5.1 Intermodal Transfer Facility (ITF) at Timpie, Utah

If the transport of SNF to the proposed PFSF occurs totally by rail (as would be the case if the new Skunk Ridge rail siding and rail line is constructed; see Chapter 2 of this FEIS), any doses during railcar switching or railyard operations would be covered by the RADTRAN4 rail transport calculation. However, if the SNF shipping casks are transferred from railcars onto heavy-haul tractor/trailers (as would be the case if an ITF is constructed near Timpie, Utah; see Chapter 2 of this FEIS), then additional dose calculations would apply. This subsection describes such calculations.

Timpie, Utah, is the proposed location on the Union Pacific rail line at which the intermodal transfer of casks from rail to tractor/trailer would take place. A new rail siding and cask handling equipment would be available at the Timpie ITF. The transfer activities that are expected to take place include radiation monitoring during the transfer, release of the shipping canister tiedowns from the railcar, hoisting the cask off of the railcar with a crane and moving it to a heavy-haul trailer, and re-securing the cask to the trailer.

At Timpie, the crew is assumed to consist of four handlers and a spotter, two inspectors, a crane operator and a health physicist. The handlers would attach lifting and rigging equipment to the ends of the cask after it is released from the railcar and help guide it into a saddle on the trailer. The spotter would give directions to the crane operator and the handlers. The inspectors would ensure that all written operating procedures are followed. The health physicist would monitor the movement and check the cask surface for radiation levels.

An equation for estimating the dose received by workers who interact with the SNF canister during the transportation transfer link is built into the RADTRAN4 code, and is described in the documentation (Neuhauser and Weiner 1992) where it is applied to the process of intermodal transfer of SNF shipping casks from one vehicle mode to another a (ship to a truck). The equation is as follows:

$$D = [(K \times DR \times PPS)/r] \times [T_H \times PPH \times N_H \times SPY] \qquad \text{Eq. D.3}$$

where,

D	=	dose in person-mrem
K	=	line source coefficient = $(1+d_{eff}/2)$
d_{eff}	=	the effective shipping cask dimension, in meters [= 4.68 m (15.4 ft) for this calculation]
DR	=	dose rate in mrem/hr at 1 m from the shipping cask surface [= 0.13 mSv/h (13 mrem/h)] for this calculation
PPS	=	shipping casks per shipment (= 4 for this calculation)
T_H	=	exposure time, in hours
PPH	=	number of staff personnel
N_H	=	number of handlings per shipment
SPY	=	number of shipments (= 1 for this calculation), and
r	=	distance of handler from the source, in meters

Each of the four handlers would be expected to spend an average of 15 minutes at a distance of approximately 1 m (3 ft) from the cask before and/or during the transfer of each cask. The health physicist would be expected to average about 5 minutes also at a distance of 1 m (3 ft) from the cask. Each inspector would be expected to spend around 5 minutes within 2 m (6.6 ft) of the cask. A spotter would be expected to remain about 2 m (6.6 ft) away from the cask for a period of 15 minutes. The crane operator may spend 30 minutes in his cab while handling each cask; his cab would be located about 6 m (20 ft) from the cask.

Apart from the time these team members would be physically helping with the cask transfer, they are expected to retreat to an area some distance from the cask where the dose rate is negligible. As the team gets more experienced in the transfer operations, it would be expected that the dose rate received by the various intermodal transfer personnel would be reduced from what is calculated below using Eq. D.3.

Table D.6 shows the estimated doses to the handlers, the spotter, the health physicist, crane operator, and the inspector associated with the unloading of four casks from a single train. The last column in the table indicates the estimated doses for all 50 trains expected in a 1-year period. For comparison, the allowable annual occupational whole-body dose for any one person in restricted-access areas, as cited in 10 CFR 20.1202(1)(i), is 50 mSv/yr (5,000 mrem/yr).

If the ITF is built at Timpie, it is assumed it will include concrete shadow shields strategically placed to shield the unloading crew as well as any member of the public that might drive close to the facility when spent fuel casks are present, awaiting transfer to a trailer and movement to the PFSF.

D.1.5.2 Intermodal Transfers from Reactor Sites Without Rail Access

Some NRC-licensed reactors do not have direct rail access. If the licensees of those reactors were to transport spent fuel for storage at the proposed PFSF, they may decide to transfer the spent fuel casks by barge or heavy haul truck (HHT) a short distance (relative to the overall route length) to the nearest railhead for loading onto railcars. The shipment would continue from that location via dedicated train.

Table D.6. Estimated one-year doses to intermodal transfer personnel

Personnel	Number of people	Distance from source [meters (ft)]	Exposure time (hours)	Dose per train, person-mSv, (person-mrem)	Dose per year, person-mSv, (person-mrem)
Handlers	4	1 (3)	0.25	1.74 (174)	87.0 (8,700)
Spotter	1	2 (6)	0.25	0.22 (22)	11.0 (1,100)
Inspectors	2	2 (6)	0.083	0.14 (14)	7.0 (700)
Health physicist	1	1 (3)	0.083	0.14 (14)	7.0 (700)
Crane operator	1	6 (18)	0.5	0.14 (14)	7.0 (700)
Total				2.38 (238)	119 (11,900)

The representative route from Maine Yankee (MY) to PFSF is intended to adequately characterize risks of shipments, regardless of their use of intermodal transfer. Therefore, the specifics of which reactors would utilize an intermodal option are not material to the FEIS conclusions. To evaluate if the impacts of such activities are reflected by the MY to PFS representative route, the NRC staff has reviewed two example cases:

1. Shipment via HHT from the Salem power plant in New Jersey to a railhead that is 24 km (15 miles) northeast of the plant, then shipment by dedicated train from there to the ITF in Timpie; and
2. Shipment via barge from the St. Lucie power plant, by two routes: either 140 km to Ft. Lauderdale, FL, or 3185 km to St. Louis, Missouri, then shipment by dedicated train from there to the ITF in Timpie.

The results from the INTERLINE and RADTRAN codes were used to compare each of these intermodal routes to the MY to PFS representative route. Because all the routes being compared will always share the route segment from the ITF in Timpie to the PFSF, this segment of the route was neglected to simplify the presentation of the comparisons (the risks of the options for transport from the ITF to PFSF are the same for all cases). Both worker and public, incident-free and accident, radiological risks were considered.

The St. Lucie and Salem plants were selected solely as examples. The licensees of these plants may or may not decide to ship their spent fuel to PFS for storage, and they may use intermodal options and routes different than those analyzed by NRC in this EIS. The NRC staff selected these intermodal options and routes using its professional judgment and the INTERLINE routing code, in consideration of the combination of route length and population density for the intermodal segment of these shipments. As a result, the staff believes the routes selected represent conservative benchmarks for comparison purposes.

Two potential barge routes from the St. Lucie plant are considered in this FEIS. The first proceeds via the St. Lucie Canal to Florida’s west coast, across the Gulf of Mexico, and up the Mississippi River to a railhead in St. Louis. It is the route selected by the INTERLINE code and represents a very long barge route traveling through lower population density areas. The second route proceeds down the intercoastal waterway in Florida to a railhead in Ft. Lauderdale. This route was examined by DOE in the DEIS for the proposed high-level waste repository at Yucca Mt., Nevada. It is a long route compared to other plants that might use barge, and it travels through high population density areas for a large fraction of its length.

***Incident-free doses*.** The incident-free radiological impacts include the dose to the crew and public during the HHT or barge movement, to workers and handlers while transferring the cask at the railhead, and to the crew and public during the rail transport segment. The total doses calculated for the intermodal example routes are compared to the total incident free doses calculated for the MY to Timpie representative route. Due to separation distance, this analysis assumes doses to the public while transferring modes at the railhead are negligible.

Because there is no expected difference in the significant parameters describing an intermodal transfer from a heavy-haul truck or barge to a rail car and a transfer from a rail car to a heavy-haul truck at the ITF, results calculated for the ITF transfer (0.12 person-Sv for 200 cask transfers in 1 year) were applied to the transfers near the nuclear plant shipment origin. Table D.6 in Section D.1.5.1 describes the derivation of this dose.

Table D.7 reports the RADTRAN incident-free results for transport of 200 casks using the various intermodal options, the MY to Timpie ITF representative route by rail, and the Timpie ITF to PFS route via HHT southward on Skull Valley Road (the latter two are also presented in Tables 5.15 and 5.16, respectively). Although no single reactor is likely to ship 200 casks in one year, these results are presented in the same format as the Maine Yankee values for ease of comparison to the representative route (i.e., Maine Yankee to PFSF) results. Thus, the tables show results ‘scaled’ to 200 casks per year by multiplying per cask dose by 200.

The relatively small crew doses for barge transport listed in Table D.7 reflect very limited exposure of the crew to the casks (resulting from one 1-minute inspection per cask per day). The doses to the heavy-haul truck driver and the escorts were calculated in the same manner as for the ITF to PFSF route. The values in the table for near-reactor intermodal operations may be compared to those for the ITF to PSFS route, showing that the crew doses are somewhat smaller while the public doses are higher. The higher public doses are to be expected because of the much higher population densities along these routes compared to Skull Valley Road.

A comparison of the total Salem to Timpie and St. Lucie to Timpie entries in Table D.7, to the Maine Yankee to Timpie entry shows that the incident-free dose estimates for 200 casks are higher for the reactor sites using intermodal transfers. However, the dose estimates do not differ greatly and are all still less than NUREG-0170 levels discussed in Sections 5.7.2.1 and 5.7.2.3 and Table 5.5 of this FEIS. Based on nationwide reactor locations and rail access distance to the PFSF, most routes to the PFSF would have lower risks than the MY to PFSF representative route; some routes could have higher risks such as the examples selected here (to be conservative, the staff intentionally selected examples with high combinations of route length and population density).

Table D.7. Incident-Free dose comparison of intermodal examples and Maine Yankee to PFS route

Route information			Incident-free doses for 200 casks shipped, person-Sv		
Origin/destination	**Length, km**	**Population**	**Public**	**Crew**	**Total**
Salem to Salem Railhead (Heavy Haul Truck)	24	6.9×10^{3}	1.9×10^{-2}	3.1×10^{-3}	2.2×10^{-2}
Intermodal transfer to railcar	N/A	Crew of 9	0	0.12	0.12
Salem Railhead to Timpie (Rail)	3907	2.0×10^{6}	9.0×10^{-2}	1.1×10^{-2}	0.10
Total Salem to Timpie	**3931**	$\mathbf{2.0 \times 10^{6}}$	**0.11**	**0.13**	**0.24**
St. Lucie to St. Louis (Barge)	3185	2.6×10^{5}	0.40	6.8×10^{-3}	0.41
Intermodal transfer to railcar	N/A	Crew of 9	0	0.12	0.12
St. Louis to Timpie (Rail)	2350	3.5×10^{5}	2.1×10^{-2}	8.9×10^{-3}	3.0×10^{-2}
Total St. Lucie to Timpie via barge to St Louis	**5535**	$\mathbf{6.1 \times 10^{5}}$	**0.42**	**0.14**	**0.56**
St. Lucie to Ft. Lauderdale (Barge)	140	2.6×10^{5}	0.24	6.7×10^{-4}	0.24
Intermodal transfer to railcar	N/A	Crew of 9	0	0.12	0.12
Ft. Lauderdale to Timpie (Rail)	4580	1.1×10^{6}	7.7×10^{-2}	1.2×10^{-2}	8.9×10^{-2}
Total St. Lucie to Timpie via barge to Ft. Lauderdale	**4720**	$\mathbf{1.4 \times 10^{6}}$	**0.32**	**0.13**	**0.45**
Maine Yankee to Timpie (Rail)	4383	1.8×10^{6}	9.2×10^{-2}	1.2×10^{-2}	**0.10**
Timpie to PFSF (Heavy Haul Truck) (common to all options)	42	1.1×10^{2}	2.0×10^{-3}	0.13	**0.13**

The NRC staff believes that the MY to PFSF route, as used in this FEIS, is representative and conservatively bounds the nationwide incident-free transportation risks, because the staff considered all 4000 casks to be stored at PFS as originating at Maine Yankee, a long route with high population. For perspective, Table J-6 of the DEIS for Yucca Mountain [DOE 1999] estimates that the total current plus projected (i.e., until end of operations) spent fuel for Salem Units 1 and 2 could be transported in 304 21-PWR assembly rail casks (the system required by the PFSF holds 24 PWR assemblies, see Table 2.5 of this FEIS). Similarly, DOE estimated that the St. Lucie Unit 2 plant's total current plus projected spent fuel could be transported in 140 21-PWR-assembly rail casks. The Yucca Mountain

DEIS evaluates St. Lucie Unit 2, and not St. Lucie Unit 1, because DOE stated that St. Lucie Unit 1 would use truck casks, meaning the system that is required by PFS would not be an option for it.

To represent and conservatively characterize transport risk, this FEIS assumes 4000 casks travel on the same MY to PFSF rail route and concludes that the resultant nationwide incident-free transportation risk impacts are small. In looking at whether or not the MY to PFSF route also adequately represents near-reactor intermodal operations, the NRC staff has considered: (1) the magnitude of the differences in dose estimates between the MY to PFSF route and routes that might include near-reactor intermodal options, and (2) the number of shipments that could be expected to originate from any given plant. The NRC staff concludes that the MY to PFSF representative rail route, as used in the FEIS, conservatively characterizes the nationwide incident-free transportation risks of the proposed action, including potential intermodal transfers.

Accident impacts. The accident radiological impacts consider accidents that might occur during the HHT or barge transportation segment and accidents that might occur during the rail transport segment. The accident dose risk calculated for the intermodal example routes are compared to the accident dose risk calculated for the MY to Timpie representative route. Accidents at the intermodal transfer point could not reasonably be expected to be more challenging to casks than the 10 CFR Part 71 certification tests (e.g., casks would not be lifted more than 9 m (30 ft)); therefore, accidents at the ITF leading to release are considered remote and speculative events. Because non-radiological accident impacts would not be substantially different for different modes of transport, only radiological impacts are considered when comparing the intermodal examples to the MY to PFS representative route.

For the HHT transport from the Salem nuclear plant to Salem, NJ, the same parameters were used as for the ITF to PFSF calculation except for the route-specific values (length, population density, etc.). For barge transport from the St. Lucie plant to Ft. Lauderdale, Florida, or St. Louis Missouri, an accident rate of 0.53 per million shipment kilometers (Saricks and Tompkins 1999, Table 8b) was used with other parameters calculated by INTERLINE to characterize the routes. Note that this accident rate is approximately one tenth of that used in NUREG-0170, which was based on much less specific data. In addition, a set of conditional accident probabilities (i.e., severity fractions), developed for the Yucca Mountain DEIS (see DOE 1999; Table J-31) to correlate with the same set of release fractions described in Table D.4, was used.

The accident dose risks calculated using RADTRAN4 for these routes are presented in Table D.8. These values are substantially higher than those for the Skull Valley route (e.g. 0.000011 person-Sv for 200 shipments in 1 year) due to the much higher population densities neighboring these route segments.

The risk estimate for any individual shipment (200 cask values in the tables divided by 50, for 4 casks per shipment) is higher for the cases requiring intermodal transport at the point of origin. However, the accident risk is lower than the value estimated by in NUREG-0170, (see Table 5.7 of this EIS).

Table D.8 Accident risk comparison of intermodal examples and Maine Yankee to PFS route

Route information			Accident risk for 200 casks shipped
Origin/destination	**Length, km**	**Population (Upper Bound)**	**LCF***
Salem to Salem Railhead (Heavy Haul Truck)	24	3.1×10^{6}	5.0×10^{-5}
Intermodal transfer to railcar	N/A	Crew of 9	0
Salem Railhead to Timpie (Rail)	3907	4.3×10^{6}	2.4×10^{-3}
Total Salem to Timpie	**3931**	$\mathbf{7.4 \times 10^{6}}$	$\mathbf{2.5 \times 10^{-3}}$
St. Lucie to St. Louis (Barge)	3185	4.3×10^{6}	4.6×10^{-2}
Intermodal transfer to railcar	N/A	Crew of 9	0
St. Louis to Timpie (Rail)	2350	3.9×10^{6}	4.8×10^{-4}
Total St. Lucie to Timpie via barge to St Louis	**5535**	$\mathbf{8.2 \times 10^{6}}$	$\mathbf{4.6 \times 10^{-2}}$
St. Lucie to Ft. Lauderdale (Barge)	140	4.3×10^{6}	3.9×10^{-2}
Intermodal transfer to railcar	N/A	Crew of 9	0
Ft. Lauderdale to Timpie (Rail)	4580	3.8×10^{6}	1.6×10^{-3}
Total St. Lucie to Timpie via barge to Ft. Lauderdale	**4720**	$\mathbf{8.1 \times 10^{6}}$	$\mathbf{4.1 \times 10^{-2}}$
Maine Yankee to Timpie (Rail)	4383	4.4×10^{6}	4.4×10^{6}
Timpie to PSFS (Heavy Haul Truck) (common to all options)	42	2.3×10^{3}	4.4×10^{-7}

* *Note:* for an explanation of the numerical LCF values, please refer to the dialogue box in Section 5.7.2

To represent and conservatively characterize transport risk, this FEIS assumes 4000 casks travel on the same MY to PFSF rail route and concludes that the resultant nationwide accident transportation risk impacts are small. In looking at whether or not the MY to PFSF route also adequately represents near-reactor intermodal operations, the NRC staff has considered: (1) the magnitude of the differences in dose estimates between the MY to PFSF route and routes that might include near-reactor intermodal options, and (2) the number of shipments that could be expected to originate from any given plant. NUREG/CR-6672 shows that the urban, suburban, and rural route fractions and population densities for the MY-PFS route are very close to the means of the distributions of these parameters constructed for NUREG/CR-6672. Therefore, since this route is 4489 km long while the mean of the NUREG/CR-6672 route length distribution is 2560 km, risks calculated using the MY-PFS are conservative. Accordingly, the NRC staff concludes that the MY to PFSF representative rail route, as used in the FEIS, conservatively characterizes the nationwide accident transportation risks of the proposed action, including potential intermodal transfers.

D.2 Summary of NUREG-0170

NUREG-0170 (NRC 1977) examined impacts from transporting all licensed material by land, air, and sea transport modes under both incident-free and accident conditions. One of the radioactive materials examined by NUREG-0170 was SNF. For SNF shipments that occur without accidents (incident-free transport), radiation doses were estimated for members of the general public who would be exposed to radiation, for example, because they lived near the shipment route, and also for workers (e.g., crew, handlers, inspectors). Release of radioactive materials from SNF to the environment as a result of transportation accidents, the probability of these releases, and the LCFs that such releases might cause were also estimated. For NUREG-0170, SNF transport risks were estimated for shipment by truck and by train over a generic highway and a generic rail route. Table 5.8 in Chapter 5 of this FEIS shows the NUREG-0170 generic rail route information.

NUREG-0170 contains an assessment of SNF shipment risk using the 1975 level of shipments, and a projection of risks for 1985, based on the assumption of a reprocessing fuel cycle. Sandia National Laboratories conducted the risk assessment for NRC, and developed the original RADTRAN (RADTRAN 1) radioactive material transport risk code, to perform the related dose calculations.

Considering the information developed and received during development of NUREG-0170, and the safety record associated with the transportation of radioactive material, the Commission determined that the regulations then in place (which for spent fuel packaging are very similar to today's regulations) were adequate to protect the public against unreasonable risk from the transport of radioactive materials, and that no immediate changes in the regulations were needed to improve safety (46 *Fed. Reg.* 21619).

For accidents, NUREG-0170 considered two release models, Model I and Model II. For calculations of radiological consequences that might be caused by accidents, accidents were divided into eight categories (Categories I through VIII) of increasing severity. Because little information relating the response of shipping casks to accident environments (NRC 1977) was available in 1975 for SNF and other highly radioactive materials shipped in Type B casks, release of radioactivity as a result of accidents was examined using two release models. Model I assumed that zero release occurs up to the regulatory test level and that the packaging fails catastrophically in all environments that exceed that level (NRC 1977). Each radionuclide was assumed to be released to the environment by this "catastrophic" failure; thus, Model I assumed that the radioactive release would take place whenever a Type B shipping cask was subjected to mechanical or thermal loads in excess of the mechanical and thermal loads encountered during shipping cask certification tests (see 10 CFR 71.73). Because the Model I cask release behavior was considered to be unrealistic (shipping casks would yield gradually, and they generally would not fail catastrophically), a second release model (Model II) was formulated. In Model II, for accidents that exceed the regulatory test level, release fractions increased more gradually with accident severity, eventually becoming equal to Model I for the last three accident severity levels.

D.3 Regional Transportation Risks Near Skull Valley, Utah

This section discusses the projected radiation dose from transporting the SNF casks to the proposed PFSF in Skull Valley using identified rail access routes and the average population densities along those routes. The results from the radiological transportation risk assessment include the radiological impacts to the general population, workers, and a hypothetical maximum exposed individual (MEI) with emphasis on the Salt Lake City and Skull Valley region. The results are also presented in terms of LCFs.

The transportation risk assessment was performed using the INTERLINE routing code and the RADTRAN4 risk assessment code to determine the cumulative transportation impacts in Utah and neighboring states associated with the transport of commercial SNF. The impacts considered were the human health effects associated both with normal transport (incident-free) and with potential accidents severe enough to release radioactive material.

Because of the size and weight of the SNF shipping casks included in the PFS application for a license, shipment by rail is the only viable cross-country transportation option. Therefore, the focus of the analysis below is on rail transportation.

D.3.1 Identification of Routes

The INTERLINE computer code model was used to select routes and analyze the transportation scenarios (see Appendix C of this FEIS). For the purpose of this analysis, it is assumed that all SNF transported to the proposed PFSF in Skull Valley, Utah, will be shipped by rail. While shipment of SNF by truck over highways is possible, the size of the proposed shipping cask system to be used for the proposed PFSF makes the use of rail transportation essential for the transport of SNF. Only when the shipments approach the proposed PFSF (e.g., at Timpie, UT), would transport by truck (i.e., heavy-haul vehicle) for the remaining short distance become viable.

Currently, there is no direct rail access to the proposed PFSF in Skull Valley. This analysis assumes that a new 51-km (32-mile) rail line would be constructed from Skunk Ridge (located northeast of the Low passing siding) to the proposed PFSF site (see Chapter 2 of this FEIS). The Union Pacific Railroad owns the existing rail line at Skunk Ridge. Rail access routes and route lengths were selected as discussed in Appendix C of this FEIS.

D.3.1.1 Shipment Modes and Destinations

Rail shipments through Skull Valley. Although shipments are expected to be made to the proposed PFSF by rail, no rail connection currently exists at the main Union Pacific trackage that passes north of the Reservation. One shipping scenario is that a rail line would be extended from a junction at Skunk Ridge to the proposed PFSF. Once the new rail line is constructed, the expected operation of the transportation system would be to bring the cask-carrying railcars by the Union Pacific system to the new Skunk Ridge siding and to then couple the railcars (with the SNF shipping casks) to dedicated locomotives that would haul the casks to the proposed PFSF. The transport workers would park the cask cars and uncouple them from the locomotive on the rail siding. PFSF workers would take several minutes to couple their locomotive to the cask cars, inspect the cars for any defects, test brake line pressure, and travel down the 51-km (32-mile) line to the proposed PFSF.

There are five possible rail routes within a 250-mile radius of the PFSF that could bring SNF shipping canisters to the Skunk Ridge siding area. As discussed in Appendix C, they include as starting points Black Rock, UT, Carlin, NV, Granger, WY, Green River, UT, and Pocatello, ID. Because it is difficult to tell at this time how much SNF each reactor would transfer to the proposed PFSF and which routes they might use, it was assumed that all 200 cask shipments each year move along each of the routes that have been identified. This assumption provides a conservative, upper-bound result for the exposure of the population along each route. Because each route is expected to carry only some of the total number of shipments, the actual exposures should be considerably less than the exposures computed along any of the routes shown. The results of the RADTRAN4 computer runs for these shipments are discussed below. The exposure data are presented in Table D.9.

Truck shipments through Skull Valley. If the new rail line is not built from Skunk Ridge, the Timpie siding is the proposed location on the Union Pacific rail line at which an ITF would be built. The ITF is the facility at which the transfer of SNF shipping casks from rail to heavy haul truck would take place. The casks would have to be moved the last 41 km (26 miles) to the proposed PFSF by HHT. A rail siding and cask handling equipment would be available at the ITF site. It is anticipated that four casks would come to the ITF each week, 50 weeks a year. One of the casks would be off-loaded from its railcar and would be placed on a heavy-haul trailer for truck transportation to the proposed PFSF (see Chapter 2 of this FEIS). The other three casks would remain on the railcars stopped on the rail siding awaiting transfer to the HHT and transportation to the PFSF.

The cask transfer activities that are expected to take place at the ITF include radiation monitoring during the cask transfer, release of the shipping canister tiedowns from the railcar, hoisting the cask off of the railcar with a crane and moving it to the heavy-haul trailer, and re-securing the cask to the trailer. Transfers would be made only during daylight hours.

At the ITF, the crew is assumed to consist of four handlers and a spotter, two inspectors, a crane operator and a health physicist. The handlers would attach ropes to the ends of the cask after it is released from the railcar and help guide it into a tie-down cradle on the low-boy trailer or to the temporary storage location. The spotter would give directions to the crane operator and the handlers. The inspectors would ensure that all written procedures are followed. The health physicist would monitor the movement and check the cask surfaces. The equation for estimating the dose received by the ITF crew is built into the RADTRAN4 code and has been used to estimate the dose received by handlers and inspectors in an intermodal transfer of SNF shipping casks (Neuhauser and Weiner 1992). Using similar exposure times, the total dose received by the ITF staff is 0.119 person-Sv/yr (11.9 person-rem/yr), or 2.38 person-Sv (238 person-rem) over a 20-year period of shipping SNF to Skull Valley.

Each heavy haul truck shipment to the PFSF from the ITF would be accompanied by escorts: one in front and one at the rear of the heavy-haul tractor/trailer in accordance with Utah Department of Transportation Regulations for Legal and Permitted Vehicles, Section 600. The heavy-haul tractor/trailer would be expected to travel at a speed of about 32 km/hr (20 mph) over the 41 km (26-mile) road to the PFSF. The trip would take approximately 1.5 hours. It is anticipated that the two escort vehicles will travel up to 300 m (1,000 ft) ahead of and behind the heavy-haul tractor/trailer to warn travelers of the slow moving truck. Once unloaded, the heavy-haul tractor/trailer and escorts can return to the ITF and pick up the next cask.

Table D.9. Summary of doses shipped to the proposed PFSF by rail via the proposed Skunk Ridge siding

To PFSF from:	Annual dose, 200 casks per year				20 year life campaign[a]			
	Crew dose, [person-Sv (person-rem)]	Pop. dose, [person-Sv (person-rem)]	MEI, [Sv (rem)]	Accident pop. dose[b] [person-Sv (person-rem)]	Crew dose, [person-Sv (person-rem)]	Pop. dose, [person-Sv (person-rem)]	MEI, [Sv (rem)]	Accident pop. dose[b] [person-Sv (person-rem)]
Black Rock, UT	0.00412 (0.412)	0.00091 (0.091)	1.11×10^{-6} (1.11×10^{-4})	0.000188 (0.0188)	0.0824 (8.24)	0.0182 (1.82)	2.22×10^{-5} (2.22×10^{-3})	0.00376 (0.376)
Carlin, NV	0.0041 (0.41)	0.000624 (0.0624)	1.11×10^{-6} (1.11×10^{-4})	0.000113 (0.0113)	0.0820 (8.20	0.0125 (1.25)	2.22×10^{-5} (2.22×10^{-3})	0.00226 (0.226)
Granger, WY	0.00590 (0.590)	0.00520 (0.520)	1.11×10^{-6} (1.11×10^{-4})	0.00237 (0.237)	0.118 (11.8)	0.104 (10.4)	2.22×10^{-5} (2.22×10^{-3})	0.0474 (4.74)
Green River, UT	0.00594 (0.594)	0.00619 (0.619)	1.11×10^{-6} (1.11×10^{-4})	0.00222 (0.222)	0.119 (11.9)	0.124 (12.4)	2.22×10^{-5} (2.22×10^{-3})	0.0444 (4.44)
Pocatello, ID	0.00588 (0.588)	0.00564 (0.564)	1.11×10^{-6} (1.11×10^{-4})	0.00233 (0.233)	0.118 (11.8)	0.113 (11.3)	2.22×10^{-5} (2.22×10^{-3})	0.04665 (4.665)

[a]Assumes all 4,000 casks shipped over the entire campaign are transferred over each of the five rail segments identified.
[b]Upper bound and assumes that all four casks all release the same amount of activity in an accident. A more likely scenario is for only one cask to release activity in a severe accident, in which case the dose received by the population in an accident would be lower by a factor of approximately 3.58.

Assuming there would be one driver in the tractor/trailer and the dose rate in the cab is at the maximum U.S. DOT limit of 0.02 Sv/hr (2 mrem/hr), the dose to the driver would not exceed 0.026 mSv (2.6 mrem) for each trip. In fact, with a single tractor/trailer designed to make this drive on a continuing basis, it would be easy to provide some small amount of additional radiation shielding for the driver, thereby reducing the driver's dose to a fraction of this amount. The PFSF driver(s) would make 200 such shipments each year. The total accumulated dose to the drivers of the tractor/trailer would not exceed:

(200 shipments/yr) × (0.026 mSv/shipment) = 5.2 mSv/yr (520 mrem/yr).

This translates to a maximum cumulative dose of 0.104 person-Sv (10.4 person-rem) for 4,000 casks shipped over a 20-year period.

Escorts. If the escorts drive an average of 240 m (800 ft) in front of and behind the shipping cask on the heavy-haul tractor/trailer, the dose rate in their vehicles, assuming no intermediate shielding such as the body of the vehicles they are riding in or the cab of the heavy haul tractor/trailer, should not exceed 2 × 10^{-6} mSv/hr (0.0002 mrem/hr) (see Figure D.2). If there are two escorts in each vehicle, the four escorts would receive:

(200 shipments/yr) × (4 persons/shipment) × [2 × 10^{-6} mSv (0.0002 mrem/hr) per person] × (1.5 hr/shipment) = 0.0024 person-mSv/yr (0.24 person-mrem/yr).

This translates to a maximum cumulative dose of 0.048 person-mSv (4.8 person-mrem) to the escorts for the entire 4,000 cask shipping campaign over 20 years.

The results of the RADTRAN4 computer runs for these intermodal shipments are discussed below, and the exposure data are presented in Tables D.10 and D.11.

D.3.1.2 Regional Radiological Impacts

The RADTRAN4 computer code (Neuhauser 1984, 1992) was used to model both the incident-free radiological exposure and the consequences of radiological releases due to severe accidents. For the regional impacts, this assessment uses the same approach as described above for the nationwide analyses.

Table D.9 summarizes the annual and the 20-year campaign radiation dose received by the crew and the public during the rail shipments from the five locations identified for the proposed PFSF in Skull Valley, assuming a new rail line is built from Skunk Ridge to the proposed PFSF. The lower exposure values received by the public when the shipments arrive via the Black Rock and Carlin locations reflect the low population densities around those rail lines compared to the higher population densities around the rail lines that reach the proposed PFSF from the Granger, Green River, and Pocatello locations.

Table D.10. Summary of annual doses shipped to the PFSF via the Timpie siding

To PFSF via Timpie, from:	Rail, annual dose[c]		Annual crew transfer dose, [person-Sv (person-rem)]	Truck, annual dose		Total annual dose	
	Crew dose, [person-Sv (person-rem)]	Pop. dose, [person-Sv (person-rem)]		Crew dose[a], [person-Sv (person-rem)]	Pop. dose[b], [person-Sv (person-rem)]	Crew dose, [person-Sv (person-rem)]	Pop. dose, [person-Sv (person-rem)]
Black Rock, UT	0.00398 (0.398)	0.00086 (0.086)	0.119 (11.9)	0.00524 (0.524)	0.00254 (0.254)	0.1282 (12.82)	0.0034 (0.34)
Carlin, NV	0.00408 (0.408)	0.00062 (0.062)	0.119 (11.9)	0.00524 (0.524)	0.00254 (0.254)	0.1283 (12.83)	0.0032 (0.32)
Granger, WY	0.00576 (0.576)	0.00515 (0.515)	0.119 (11.9)	0.00524 (0.524)	0.00254 (0.254)	0.1300 (13.00)	0.0077 (0.77)
Green River, UT	0.00580 (0.580)	0.00580 (0.580)	0.119 (11.9)	0.00524 (0.524)	0.00254 (0.254)	0.1300 (13.00)	0.0083 (0.83)
Pocatello, ID	0.00574 (0.574)	0.00556 (0.556)	0.119 (11.9)	0.00524 (0.524)	0.00254 (0.254)	0.1300 (13.00)	0.0081 (0.81)

[a]Driver plus escorts.
[b]Essentially 100 percent of this population dose is received by persons who are on-link in cars passing the truck carrying the cask.
[c]Assumes all 200 casks are shipped annually.

Table D.11. Summary of 20-year campaign doses shipped to the PFSF via the ITF near Timpie

	Rail, 20 year campaign[c]			Truck, 20 year campaign		Total dose, 20 year campaign	
To PFSF via Timpie, from:	Crew dose, [person-Sv (person-rem)]	Pop. dose, [person-Sv (person-rem)]	Crew transfer dose, 20-year [person-Sv (person-rem)]	Crew dose[a], [person-Sv (person-rem)]	Pop. dose[b], [person-Sv (person-rem)]	Crew dose, [person-Sv (person-rem)]	Pop. dose, [person-Sv (person-rem)]
Black Rock, UT	0.0796 (7.96)	0.0172 (1.72)	2.38 (238)	0.105 (10.5)	0.0510 (5.10)	2.564 (256.4)	0.068 (6.8)
Carlin, NV	0.0816 (8.16)	0.0125 (1.25)	2.38 (238)	0.105 (10.5)	0.0510 (5.10)	2.566 (256.6)	0.063 (6.3)
Granger, WY	0.115 (11.5)	0.103 (10.3)	2.38 (238)	0.105 (10.5)	0.0510 (5.10)	2.600 (260.0)	0.154 (15.4)
Green River, UT	0.116 (11.6)	0.116 (11.6)	2.38 (238)	0.105 (10.5)	0.0510 (5.10)	2.601 (260.1)	0.167 (16.7)
Pocatello, ID	0.115 (11.5)	0.111 (11.1)	2.38 (238)	0.105 (10.5)	0.0510 (5.10)	2.600 (260.0)	0.162 (16.2)

[a]Driver plus escorts.
[b]Essentially 100 percent of this population dose is received by persons who are on-link in cars passing the truck carrying the cask.
[c]Assumes all 4,000 casks shipped over the entire campaign are transferred over each of the five rail segments identified.

At the ITF, the casks would be transferred to heavy-haul tractor/trailers and moved to the proposed PFSF. Table D.10 summarizes the annual dose that the crew and the general public would receive. Table D.11 identifies the dose received during a 20-year shipping campaign by the general public and workers, e.g., handlers and inspectors at the ITF, as well as the dose received by the heavy-haul driver(s) and the escorts. The doses received by the different populations (e.g., the crews, including the cask transfer personnel at the ITF, and the general population) are summed in the far right columns of Table D.11. It is apparent from a comparison of Tables D.9 and D.11 that the working crews, particularly those that are involved with the intermodal transfer at the ITF, receive the largest potential dose. However, the dose received by the general population is also higher compared to that received under the Skunk Ridge rail line option, when the casks are shipped to the PFSF using heavy-haul tractor/trailers on Skull Valley Road and the ITF. Table D.13 summarizes the latent cancer fatality (LCF) risk that the crew and the general public would receive, and Table D.14 presents similar information, including the risks associated with the ITF option.

D.3.2 Shipments to a Final Repository

This section examines the radiological risk of transporting all 4,000 SNF canisters from the proposed PFSF to the Utah-Nevada border. The SNF would remain at the proposed PFSF for a number of years, after which it would be removed and transported to the final repository. The NRC staff performed an additional assessment of shipment of SNF from the proposed PFSF to a permanent repository. Congress, in the Nuclear Waste Policy Act (NWPA), as amended, had directed the DOE to study one candidate repository, namely a repository proposed at Yucca Mountain, Nevada. To reflect the provisions of the NWPA, the NRC staff has examined the shipment of SNF via rail from the proposed PFSF on its way to a permanent repository in the western United States as if such a repository were located at Yucca Mountain, Nevada, although that location may or may not become the actual repository. Accordingly the NRC staff examined the shipment of SNF via rail from the proposed PFSF through Black Rock, Utah, to the Utah-Nevada border. It should be noted that the NRC has not received an application requesting a license for permanent geologic repository, and the NRC has not made any determination regarding any proposal to construct such a repository at Yucca Mountain, Nevada, or any other location. DOE is not currently considering any other location. However, the NRC staff recognized that Yucca Mountain may not be selected or approved as the final repository, and the assumption made is for analytical purposes in this FEIS. Further, this EIS does not dictate any particular result for future actions taken with respect to other nuclear waste management facilities (including a repository or other storage facility).

The plans beyond the Utah border are subject to decisions that have not yet been made. Accordingly, while the NRC staff's evaluation reflects the provisions of the NWPA, the specifics and details of potential repository location, design, and operations (e.g., use of a direct rail route or an intermodal facility with heavy haul segment) that are not yet certain are not material to the assessments and conclusions in this FEIS.

For the purposes of analysis, it was assumed that the SNF in the canisters would have been cooled at least 20 years prior to shipment to a repository. It was also assumed that the shipping casks designed to bring the canisters to the PFSF would be used to ship them to the repository. These assumptions are judged reasonable because this will (1) save the cost of designing, certifying, and fabricating new casks, (2) reduce potential handling activities, and (3) reduce the dose rate from the casks because of the decay of many of the isotopes that would be inside the canisters. Comparing 5-year-old fuel with 20-year-old fuel with the same burn-up, the radioactivity of the most significant isotopes will be reduced by a factor of two. To a first approximation, the dose rate is assumed to be reduced by this

Table D.12. Summary of doses from the outbound shipments from PFSF to a permanent repository as far as the Utah-Nevada border.[a]

From PFSF to:	Annual dose, 200 casks per year[a]				20 year life campaign			
	Crew dose, [person-Sv (person-rem)]	Pop. dose, [person-Sv (person-rem)]	MEI, [Sv (rem)]	Accident pop. dose [person-Sv (person-rem)]	Crew dose, [person-Sv (person-rem)]	Pop. dose, [person-Sv (person-rem)]	MEI, [Sv (rem)]	Accident pop. dose [person-Sv (person-rem)]
Utah-Nevada border	0.00218 (0.218)	0.0008 (0.08)	5.54×10^{-7} (5.54×10^{-5})	0.000223 (0.0223)	0.0436 (4.36)	0.0160 (1.60)	1.11×10^{-5} (1.11×10^{-3})	0.00446 (0.446)

[a]Includes the shipment of 200 casks per year, each containing twenty-four 20-year cooled PWR fuel assemblies, and a dose rate of 0.065 mSv/hr (6.5 mrem/hr) at 1 m (3 ft) from the cask shipped from the PFSF by rail via the Skunk Ridge siding.

Table D.13. Summary of the cumulative annual and 20-year campaign risks for the shipment of spent nuclear fuel by rail via the Skunk Ridge siding to the proposed PFSF site in Skull Valley, Utah

To PFSF from:	Risks (LCFs) from 1 year rail shipments			Risks (LCFs) from 20 years of rail shipments		
	Incident-free risk		Accident risk[a]	Incident-free risk		Accident risk[a]
	Crew	Public	Public	Crew	Public	Public
Black Rock, UT	1.65×10^{-4}	4.55×10^{-5}	9.40×10^{-6}	3.30×10^{-3}	9.10×10^{-4}	1.88×10^{-4}
Carlin, NV	1.64×10^{-4}	3.12×10^{-5}	5.65×10^{-6}	3.28×10^{-3}	6.25×10^{-4}	1.13×10^{-4}
Granger, WY	2.36×10^{-4}	2.60×10^{-4}	1.19×10^{-4}	4.72×10^{-3}	5.20×10^{-3}	2.37×10^{-3}
Green River, UT	2.38×10^{-4}	3.10×10^{-4}	1.11×10^{-4}	4.76×10^{-3}	6.20×10^{-3}	2.22×10^{-3}
Pocatello, ID	2.35×10^{-4}	2.82×10^{-4}	1.17×10^{-4}	4.72×10^{-3}	5.65×10^{-3}	2.33×10^{-3}

[a]Upper bound and assumes that all four casks on a single train all release the same amount of activity in an accident. A more likely scenario is for only one cask to release activity in a severe accident, in which case the dose received by the population in an accident would be lower by a factor of approximately 3.58.

Table D.14. Summary of the cumulative 20-year campaign risks for the intermodal shipment of spent nuclear fuel to the proposed PFSF site via the ITF near Timpie

To PFSF via Timpie, from:	Rail risk (LCFs) incident-free		Transfer risk (LCFs) incident-free	Truck risk (LCFs) incident-free		Total risk (LCFs) incident-free		Accident risk (LCFs)
	Crew	Public	Crew	Crew	Public	Crew	Public	Public
Black Rock, UT	3.18×10^{-3}	8.60×10^{-4}	9.52×10^{-2}	4.19×10^{-3}	2.54×10^{-3}	1.03×10^{-1}	3.40×10^{-3}	1.89×10^{-4}
Carlin, NV	3.26×10^{-3}	6.25×10^{-4}	9.52×10^{-2}	4.19×10^{-3}	2.54×10^{-3}	1.03×10^{-1}	3.15×10^{-3}	1.14×10^{-4}
Granger, WY	4.60×10^{-3}	5.15×10^{-3}	9.52×10^{-2}	4.19×10^{-3}	2.54×10^{-3}	1.04×10^{-1}	7.70×10^{-3}	2.37×10^{-3}
Green River, UT	4.64×10^{-3}	5.80×10^{-3}	9.52×10^{-2}	4.19×10^{-3}	2.54×10^{-3}	1.04×10^{-1}	8.35×10^{-3}	1.77×10^{-3}
Pocatello, ID	4.60×10^{-3}	5.55×10^{-3}	9.52×10^{-2}	4.19×10^{-3}	2.54×10^{-3}	1.04×10^{-1}	8.10×10^{-3}	2.33×10^{-3}

same ratio, i.e., to 0.065 mSv/hr (6.5 mrem/hr) at a distance of 1 m (3.3 ft) from the cask surface. However, the population of Utah is expected to increase about a factor of two from 1990 (at 1.72 million) to 2040 (projected to be 3.38 million).

The doses and risks associated with SNF shipments from the proposed PFSF to the Utah-Nevada border are presented and discussed in detail in Section 5.7.2.7 of this FEIS.

D.4 Regional Transportation Risks Near the Alternate Site for the Facility in Fremont County, Wyoming

An alternative site for the proposed facility near Shoshoni, Wyoming, was also examined for this study (see Chapter 7 in this FEIS). This site is located approximately 3.2 km (2 miles) from the Burlington Northern Santa Fe (BNSF) Railway mainline that runs through central Wyoming.

D.4.1 Identification of Routes

The INTERLINE rail routing model was used to examine possible rail access routes to this alternative site. As with the access routes identified for the Skull Valley site in Utah, the actual distances of the routes to the Wyoming site vary [from about 350 km (220 miles) to 400 km (250 miles)] due to the structure of the INTERLINE rail routing network. Four different access routes could be used to service the alternative site in Wyoming. These rail routes are described and illustrated in Appendix C of this FEIS.

D.4.2 Radiological Impacts

A risk analysis similar to that developed for the Skull Valley site (see Section D.3) was carried out for the alternative Wyoming site, and all available rail routes that could be used to transfer SNF shipping casks to the site were identified as described above. The Wyoming site was assumed to receive approximately 200 casks per year (i.e., the same as the Skull Valley site). The exposure of the public and train crew will be affected by the number of casks that will be handled by any single train. Although the shipments are expected to average four casks per train into the site, each train can be expected to handle anywhere from one to six casks. Table D.3 presents the radionuclide inventory for the SNF shipments to the Wyoming site.

There are four possible rail routes that could bring SNF to the Wyoming site. As discussed in Appendix C of this FEIS, they include as starting points Crandall, WY, Gibson, WY, Mitchell, NE, and Mossmain, MT. Similar to the analysis in Section D.3, it was assumed that all 200 shipments each year move along each of the routes that have been identified. This provides a conservative, upper-bound result for the actual exposure of the population along each route. Because each route is expected to carry only some of the total shipments, the exposures should be considerably less than the exposures computed along any of the routes shown. The results of the RADTRAN4 computer runs are discussed below. The exposure data are presented in Table D.15.

Table D.16 lists the risk of LCFs expected to result from radiation exposure during incident-free transportation and accidents assuming all the shipments come to the Wyoming site on each of the four possible routes. Radiation doses to the population and rail crews were converted to estimates of LCFs using the upper limit risk coefficient suggested by the NAS (ICRP 1991; NAS 1990).

Table D.15. Summary of doses for the shipment of spent nuclear fuel to the Wyoming site by rail

To Wyoming ISFSI from:	Annual dose, 200 casks per year				20 year life campaign			
	Crew dose, [person-Sv (person-rem)]	Pop. dose, [person-Sv (person-rem)]	MEI, person-[Sv (rem)]	Accident pop. dose [person-Sv (person-rem)]	Crew dose, [person-Sv (person-rem)]	Pop. dose, [person-Sv (person-rem)]	MEI, person-[Sv (rem)]	Accident pop. dose [person-Sv (person-rem)]
Crandall, WY	0.00576 (0.576)	0.00146 (0.146)	1.11×10^{-6} (1.11×10^{-4})	7.19×10^{-4} (7.19×10^{-2})	0.115 (11.5)	0.0292 (2.29)	2.22×10^{-5} (2.22×10^{-3})	0.0144 (1.44)
Gibson, WY	0.00578 (0.578)	0.00153 (0.153)	1.11×10^{-6} (1.11×10^{-4})	7.37×10^{-4} (7.37×10^{-2})	0.116 (11.6)	0.0306 (3.06)	2.22×10^{-5} (2.22×10^{-3})	0.0147 (1.47)
Mitchell, NE	0.00584 (0.584)	0.00159 (0.159)	1.11×10^{-6} (1.11×10^{-4})	7.51×10^{-4} (7.51×10^{-2})	0.117 (11.7)	0.0318 (3.18)	2.22×10^{-5} (2.22×10^{-3})	0.0150 (1.50)
Mossmain, MT	0.00578 (0.578)	0.000884 (0.0884)	1.11×10^{-6} (1.11×10^{-4})	2.56×10^{-4} (2.56×10^{-2})	0.116 (11.6)	0.0177 (1.77)	2.22×10^{-5} (2.22×10^{-3})	0.00512 (0.512)

Table D.16. Summary of the cumulative annual and 20-year campaign risks for the shipment of spent nuclear fuel by rail to the alternative Wyoming ISFSI site

To the Wyoming site from:	Risks (LCFs) from 1 year rail shipments			Risks (LCFs) from 20 years of rail shipments		
	Incident-free risk		Accident risk	Incident-free risk		Accident risk
	Crew	Public	Public	Crew	Public	Public
Crandall, WY	2.30×10^{-4}	7.30×10^{-5}	3.60×10^{-5}	4.61×10^{-3}	1.46×10^{-3}	7.20×10^{-4}
Gibson, WY	2.31×10^{-4}	7.65×10^{-5}	3.69×10^{-5}	4.62×10^{-3}	1.53×10^{-3}	7.38×10^{-4}
Mitchell, NE	2.34×10^{-4}	7.95×10^{-5}	3.76×10^{-5}	4.67×10^{-3}	1.59×10^{-3}	7.52×10^{-4}
Mossmain, MT	2.31×10^{-4}	4.42×10^{-5}	1.28×10^{-5}	4.62×10^{-3}	8.84×10^{-4}	2.56×10^{-4}

Assuming an average of four casks are shipped on each train, this study indicates that the radiological risks of the rail shipments of SNF are quite low. In any year, the number of LCFs statistically expected to occur from the calculated exposures would not exceed 2.34×10^{-4} LCFs for the two person crew or 7.95×10^{-5} LCFs for members of the public exposed during incident-free transportation if all the shipments came through the Mitchell, NE, route. For the entire 20-year campaign, the number of LCFs statistically expected to occur from the calculated exposure data would not exceed 4.67×10^{-3} LCFs for the two-person crew or 1.59×10^{-3} LCFs for members of the public exposed during incident-free transportation if all the shipments came through the Mitchell, NE, route.

The results of the analysis indicate that the radiological risk associated with an accident is maximized on the Mitchell, NE route, but is not expected to exceed 3.76×10^{-5} LCFs in any year and 7.52×10^{-4} LCFs over the life of the campaign. The MEI who witnesses the movement of each of the 50 trains per year, each carrying four casks, at a distance of 30 m (98 ft) from the passing train, would receive 0.0011 mSv (0.11 mrem), which is 0.03 percent of the 3.0 mSv (300-mrem) average annual effective dose received from natural background radiation sources. If the MEI witnessed the movement of casks over the entire 20-year campaign, that individual would not receive a dose in excess of 0.022 mSv (2.2 mrem).

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